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WAR DEPARTMENT TECHNICAL MANUAL

U.S. Dept of Army

AIRCRAFT
MECHANICS
TOOLS

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AIRCRAFT MECHANICS TOOLS



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For explanation of symbols, see FM 21-6.

CONTENTS



	<i>Paragraphs</i>	<i>Page</i>
SECTION I. GENERAL	1	1
II. ASSEMBLY AND DISASSEMBLY TOOLS...	2-5	3
III. SPECIAL AIRCRAFT WRENCHES AND TOOLS	6-9	19
IV. MEASURING AND LAYOUT TOOLS	10-17	43
V. FABRICATING TOOLS	18-26	66
VI. POWER TOOLS	27-32	144
INDEX		153

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SECTION I

GENERAL

I. General

This manual is for the man who is going to be an airplane mechanic; who is just starting to learn what to do to keep an airplane flying. The success of the crew that flies in an airplane depends, to a large extent, on the ground mechanic. An airplane is no better than the mechanic who repairs it.

a. IMPORTANCE OF TOOLS. There are several statements that could be made about the importance of tools. The most important is this: With tools the job can be done; without them it can't.

b. IMPORTANCE OF PROPER USE AND CARE OF TOOLS. It is important that tools be used and cared for properly. If they are to function as they should, they should not be damaged through carelessness. A good mechanic can be identified by the care he gives his tools. The proper use and care of aircraft tools will be covered in this manual. When to use each one, how to use each one, and, in some cases, how not to use a tool, will be explained. Some of the student mechanics are already skilled in the use of tools; for them this manual will provide a good review. For some of the men this manual covers an entirely new field. Every student mechanic should pay particular attention to the proper use of each of the various tools because every job of airplane repair must be correctly done.

c. TOOL MATERIALS. (1) The material chosen for the manufacture of a tool depends upon the use for which it is intended. Files, for example, must be very hard. Drills are hard and tough. Wrenches are tough. Hardening a tool makes it more brittle. Tempering makes it tougher but less hard. Therefore one quality must be sacrificed in order to gain the other, and the designer must decide which is needed the more.

(2) After being shaped to size, all tools are heat treated. The tool is placed in a furnace and allowed to remain there until it reaches the proper temperature. It is then removed and quenched in water, oil, or some other liquid. This makes the tool hard. The degree of temperature and the solution used for quenching depend upon the alloy used in making the tool. After hardening, the tool is sometimes reheated to a lower temperature and again quenched. This is known as tempering the metal. It makes the metal slightly less hard, but much tougher. Again, the temperature and the quenching liquid used depend upon the alloy of the material.



Know your tools.

d. CLASSES OF TOOLS. In this manual, tools will be divided into five different classes.

(1) *General maintenance tools* will include the tools frequently used by the airplane mechanic in servicing and repairing an airplane.

(2) *Special aircraft wrenches and tools* will include those tools that are made for a particular job that the general maintenance tools will not fit.

(3) *Measuring and layout tools* will include the tools necessary to lay out the jobs to be done, and to check the accuracy of the work when it is finished.

(4) *Fabricating tools* will include the tools necessary to work the various materials used in aircraft construction to a definite shape and size.

(5) *Power tools* will include the tools (used by the airplane mechanic) which are operated by electric power and compressed air.

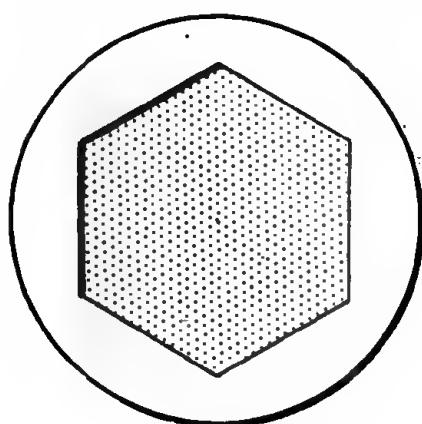
SECTION II

ASSEMBLY AND DISASSEMBLY TOOLS

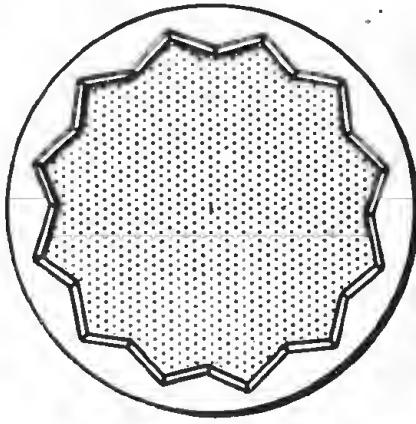
2. Wrenches

a. GENERAL. Wrenches are tools used to turn bolts and nuts in order to tighten or loosen them. They are the most common tools used by an airplane mechanic. Good wrenches are made of a relatively hard, very tough material such as chrome-molybdenum steel, so that they will not be twisted out of shape during use. The most common types of wrenches are: socket, box-end, open-end, and adjustable-jaw.

b. TYPES. (1) A socket wrench consists of a socket and handle. The socket has an opening (to fit a nut or the head of a bolt) broached in one end, and an opening (to fit the handle by means of which the wrench is turned) in the other end. The opening which fits the nut usually has 6 or 12 points. (See fig. 1.) The advantage of the 12-point socket is that the



6 POINT



12 POINT

Figure 1. Six- and twelve-point socket wrenches.

wrench need be swung only half as far as the 6-point socket before it can be refitted to another grip on the nut; it can therefore be used in closer quarters. Most sockets have 12 points. Ordinary sockets range in size from $\frac{3}{16}$ to $\frac{3}{4}$ inches. (See fig. 2.) A socket is designated according to size by the distance across the flats of the nut it fits. There are four types of handles which fit these sockets. They are: ratchet, hinged, sliding-bar, and speed. All have special advantages and the good mechanic will choose

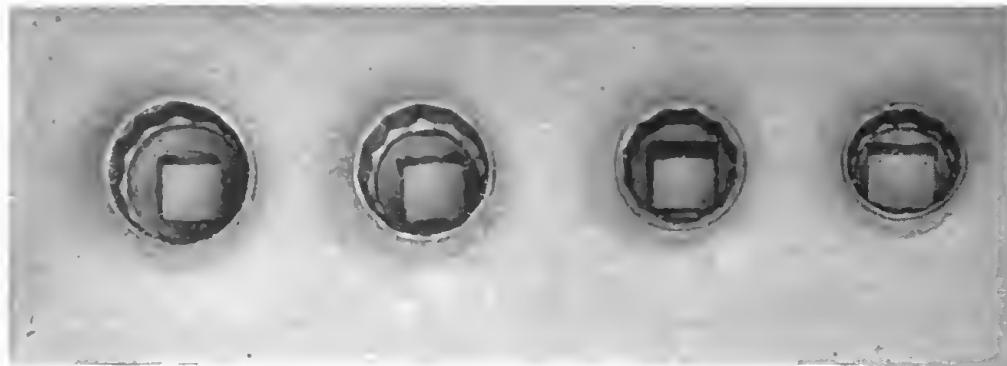


Figure 2. Socket wrenches.

the one best suited to the job at hand. In addition to the previously mentioned tools, a set of socket wrenches includes several extension bars of various lengths, one or more universal joints, and several universal sockets. One end of the bar is formed to fit a handle and the other end to fit a socket. By the use of one or more extension bars, the mechanic can get at nuts which would otherwise be out of reach. By means of the universal joints or universal socket the mechanic can work the wrench handle at an angle with the socket. (See fig. 3.)

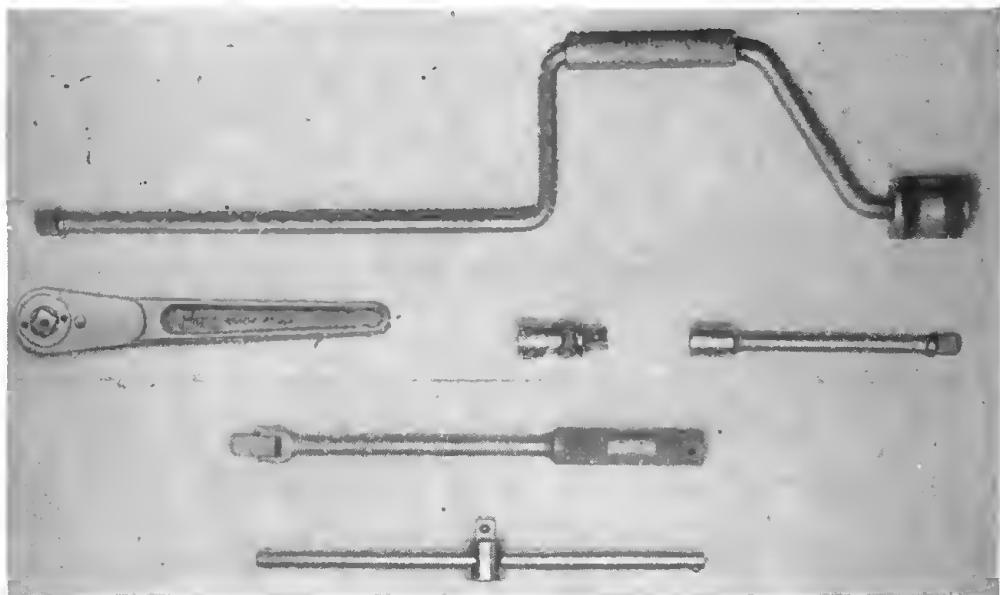


Figure 3. Set of socket-wrench handles and a universal.

(2) *A set of box-end wrenches* is included in the mechanic's tool kit. Essentially, a box-end wrench is a bar with a head on each end. Each head has a 12-point opening broached in it which will fit a nut or the head of a bolt. The two ends of each wrench fit consecutive-sized nuts such as $\frac{3}{8}$ and $\frac{7}{16}$ inches, $\frac{1}{2}$ and $\frac{9}{16}$ inches. A set includes wrenches which range in size from $\frac{5}{16}$ to 1 inch by sixteenths. (See fig. 4.)



Figure 4. Set of box-end wrenches.

(3) *The open-end wrench* is another useful wrench. It has two parallel jaws at each end of a bar. The width between the jaws determines the size of nut it will fit. The jaws of an open-end wrench are usually machined 15° from parallel to the center line of the wrench, to enable the mechanic to get a new grip after turning the nut 30° instead of 60° as would be necessary if the jaws were parallel to the center line. (See fig. 5.)

(4) *Adjustable-jaw wrenches* include crescent, auto, and pipe wrenches. (See fig. 6.) A crescent wrench is similar to an open-end wrench except that one of the jaws has a screw adjustment and can be moved to and from the other jaw. It will, therefore, fit any nut up to the maximum size for which it is manufactured. The length of the handle determines the size of an adjustable-jaw wrench. The auto wrench has a fixed jaw and

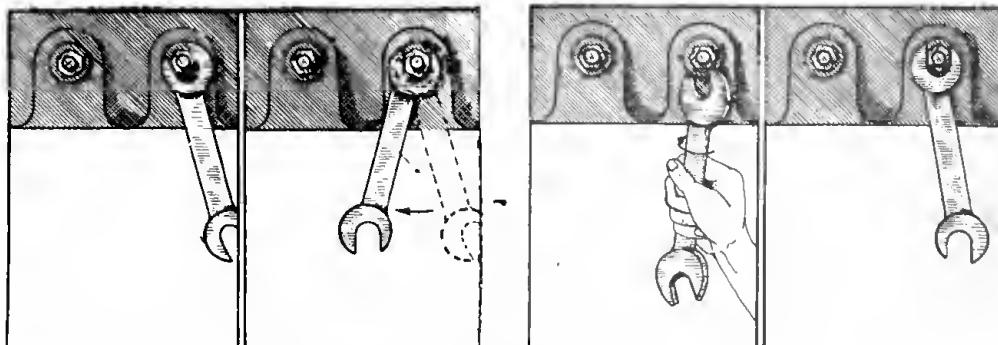
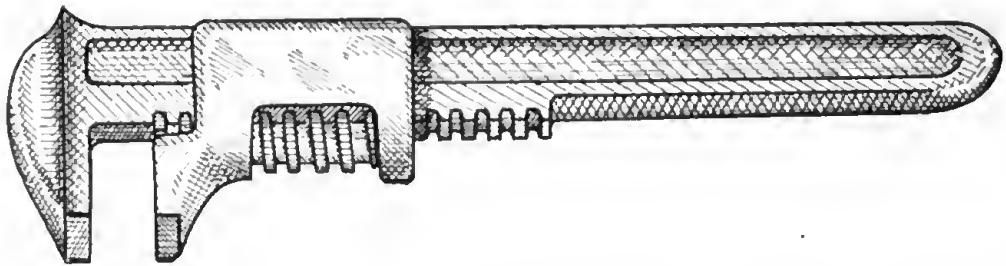
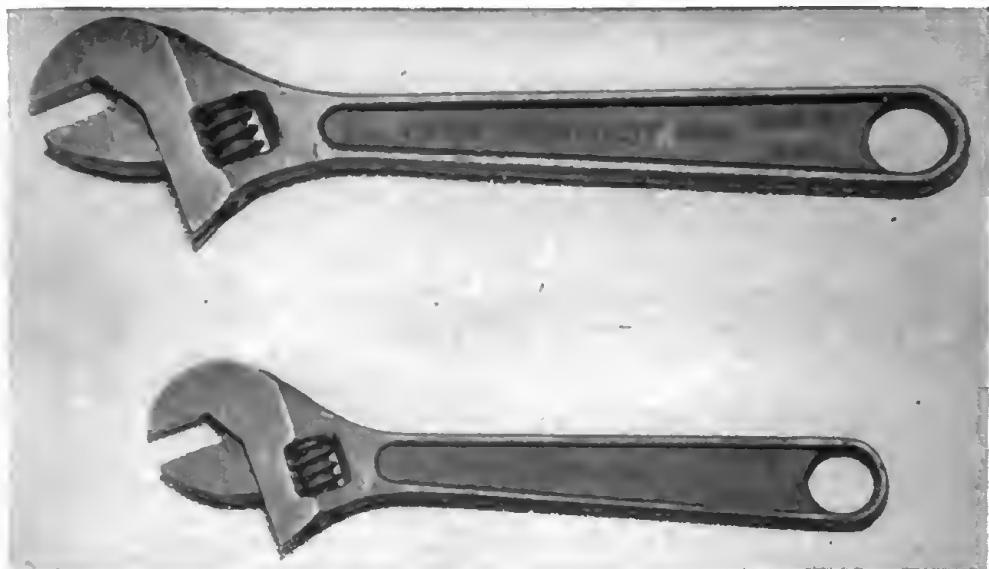


Figure 5. Using an open-end wrench.



①



②

Figure 6. Adjustable-jaw wrenches.

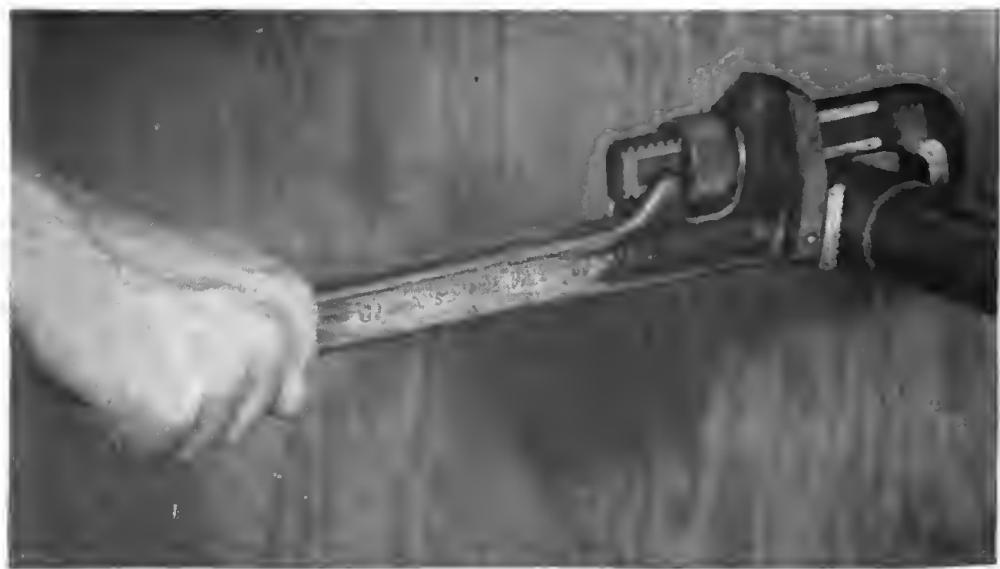


Figure 7. Pipe wrench in use.

a movable jaw, both of which are at right angles to the handle. The face of each jaw is smooth. A pipe wrench is similar to the ordinary adjustable-jaw wrench except that the adjustable jaw of the pipe wrench is so fastened that it can pivot slightly in relation to the rest of the wrench and the bearing surfaces of the jaws have teeth on them. When the handle of the wrench is pulled in the proper direction, these teeth bite into the stock to form a grip which enables the mechanic to turn it. Pushing the handle in the other direction loosens the wrench. (See fig. 7.)

(5) *Headless hexagon setscrew wrenches (also called Allen wrenches)* are merely six-sided bars in the shape of an L. (See fig. 8.) They range in size from $\frac{3}{64}$ to $\frac{1}{2}$ inch. They fit into hexagonal recesses, usually in setscrews.

(6) *Internal wrenching adapters* are used for the same purpose as Allen wrenches. One type is shown in figure 9. This type has a $\frac{1}{2}$ -inch



Figure 8. Allen wrench.

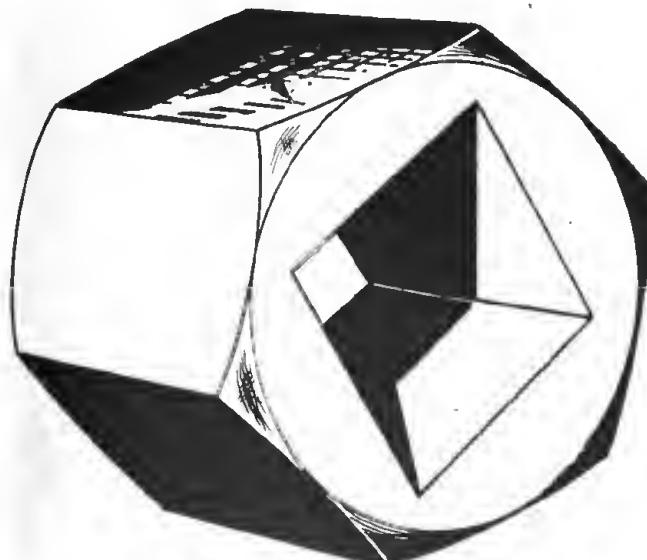


Figure 9. Internal wrenching adapter.

square drive and is used for heavy work. A smaller type is also standard. The small type has a $\frac{1}{4}$ -inch square drive and is used for light work.

(7) *A screw extractor (Ezy-out)* is not a wrench in the strict sense of the word. It is a tool used to remove broken bolts and screws. The size is indicated by a number. A complete set ranges from No. 1 to No. 10, inclusive. (See fig. 10.)

c. USE AND CARE OF WRENCHES. (1) Where applicable and practical, a socket wrench is the best tool for removing nuts and bolts. However, when reassembling parts of an airplane, the socket wrench should be used with caution. The handles are interchangeable and are made long enough to enable the mechanic to tighten the largest nuts without undue strain. If a long handle is used when tightening a small nut, there is a possibility that enough torque (twisting force) will be exerted to strip the threads or pull the bolt in two. However, if the mechanic chokes the wrench (holds it near the socket instead of at the end of the handle), it may be used satisfactorily.

(2) The length of the handle of a box-end wrench is proportional to the size of nut it fits. Therefore it is a good tool to use for the final setting of nuts, since the mechanic is not then so apt to overtighten them.

(3) Because open-end wrenches are open at the end, they can be used on tubing nuts and in other places where it would be impossible to use a box-end or socket wrench. An open-end wrench should only be used where conditions make it impossible to use a box-end or socket wrench. The box-end or a socket wrench bears against the nut on six points, whereas the open-end wrench bears against only two and is more apt to round off the corners of the nut.

(4) The adjustable-jaw wrench is one of the most commonly used

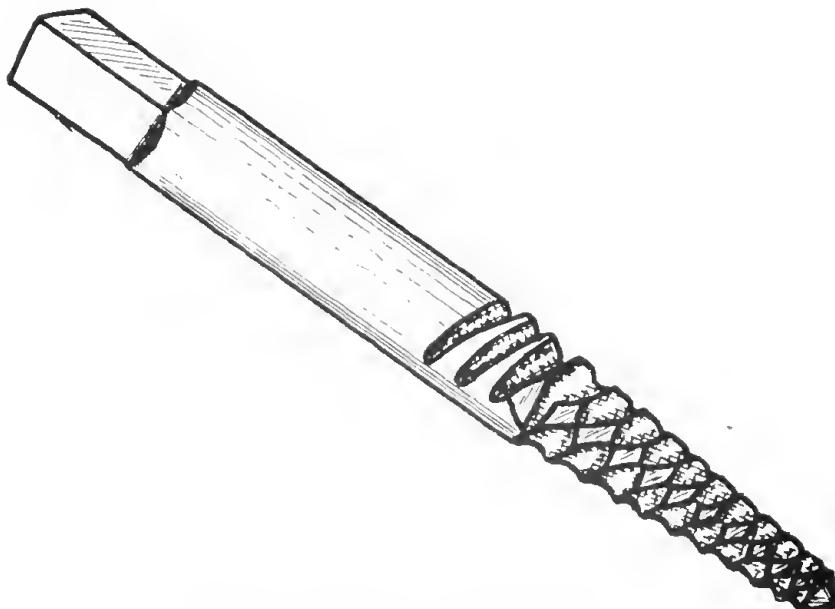


Figure 10^①. Screw extractor (Ezy-out).

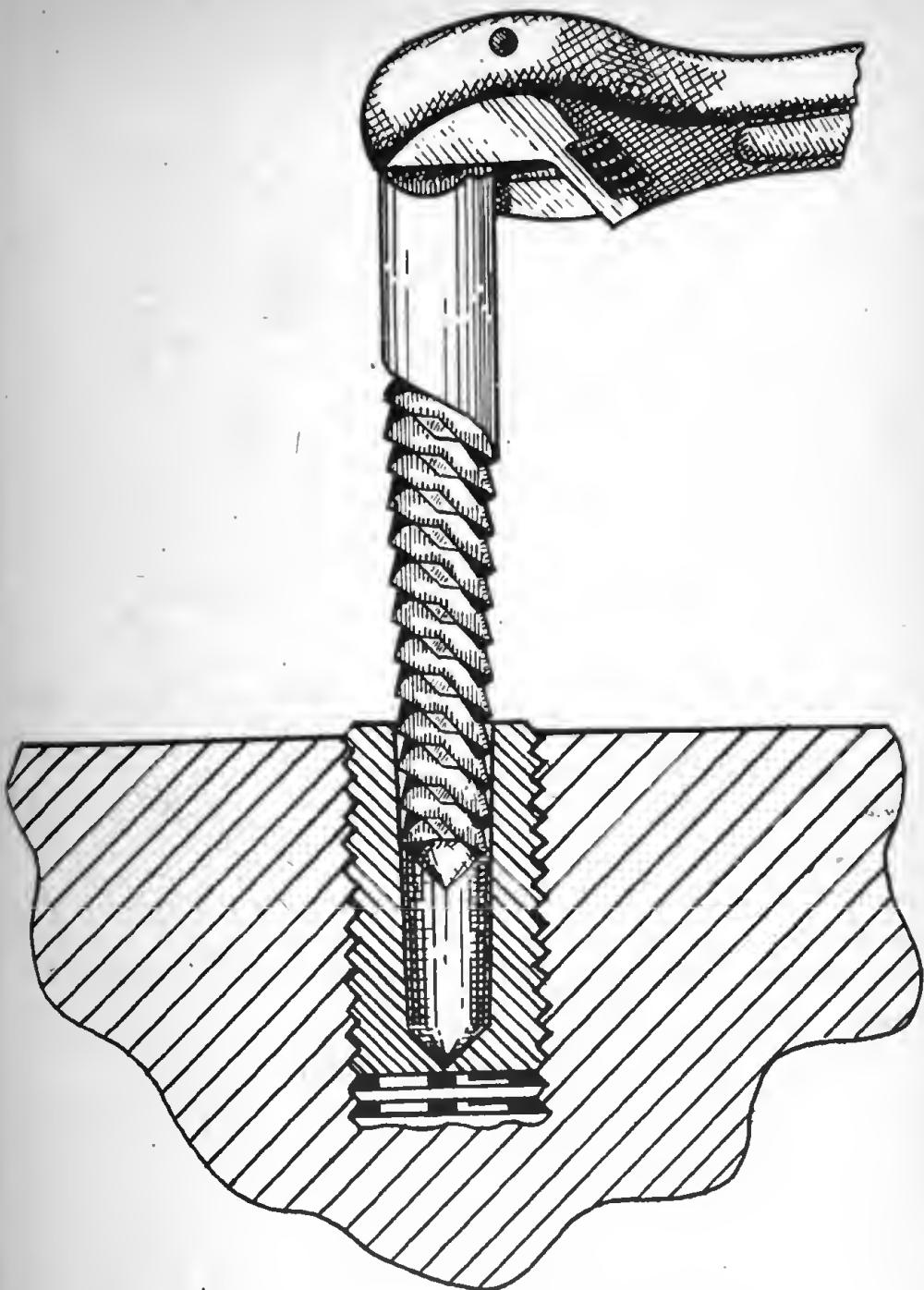


Figure 10③. Removing bolt with screw extractor.

and most commonly abused tools available to the airplane mechanic. It should be used only when other wrenches are unavailable or do not fit the nuts to be removed. One such wrench will fit any nut up to $\frac{3}{4}$ inch. For minor adjustments where the necessary torque is not too great, it works satisfactorily. Care should be exercised that the wrench is properly adjusted, since a loose-fitting wrench is more apt to round the corners

of a nut than one which fits the nut perfectly. (See fig. 11.) Shaking the wrench slightly while it is being adjusted to the nut will aid in getting a more nearly perfect fit. The wrench should also be turned in the proper

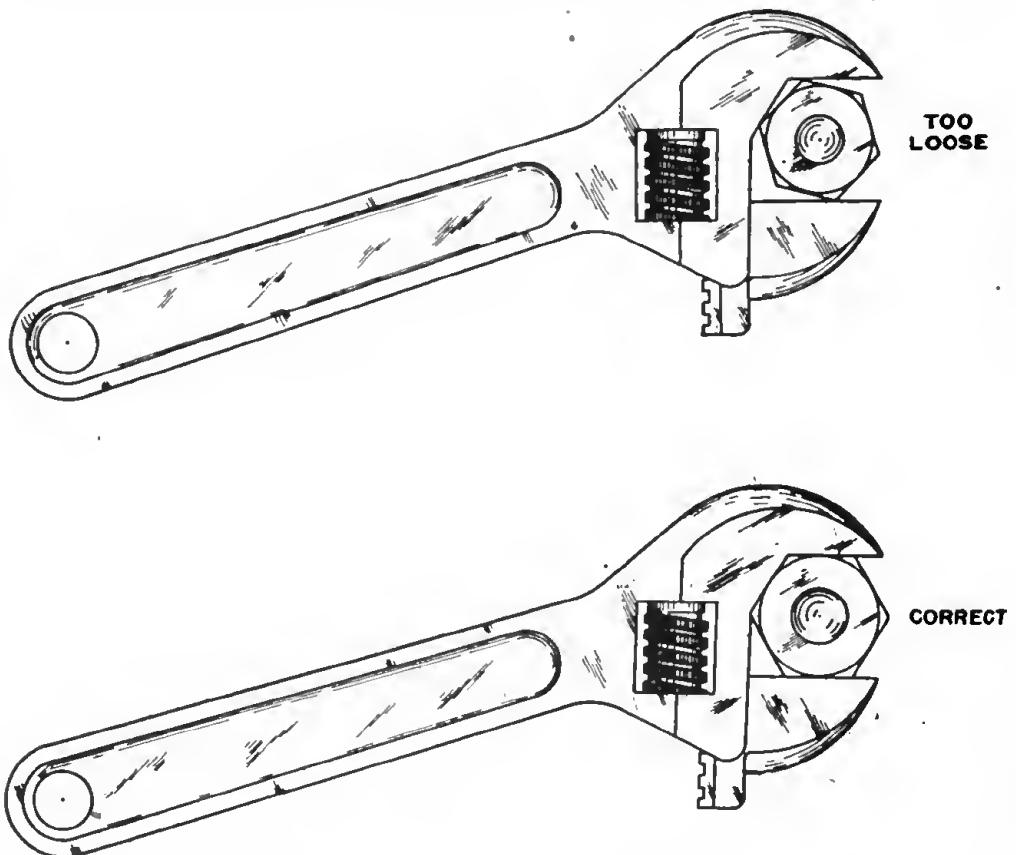


Figure 11. Correct and incorrect adjustment of an adjustable-jaw wrench.

direction. All adjustable-jaw wrenches should always be pulled so that the handle moves toward the adjustable jaw. (See fig. 12.)

(5) A pipe wrench is not to be used when assembling parts of an airplane. The teeth of the wrench leave grooves in the surface of the material which weaken it. It is used only to remove damaged parts which, because of the damage, cannot be removed by other wrenches.

(6) To remove a broken bolt with a screw extractor, the following general procedure should be followed: Locate a mark on the exact center of the bolt. Enlarge this mark with a center punch. Choose a drill with a diameter approximately half that of the bolt and, with it, drill completely through the bolt. Choose the largest-size screw extractor that will fit into the hole. With a small adjustable tap wrench, turn the extractor counterclockwise (for a bolt with right-hand threads) with a steady, even force. It will bind in the hole and unscrew the broken bolt. (See fig. 10 ②.)

(7) The quality of a mechanic can be determined by the care he gives his wrenches and other tools. He should not allow them to become exces-

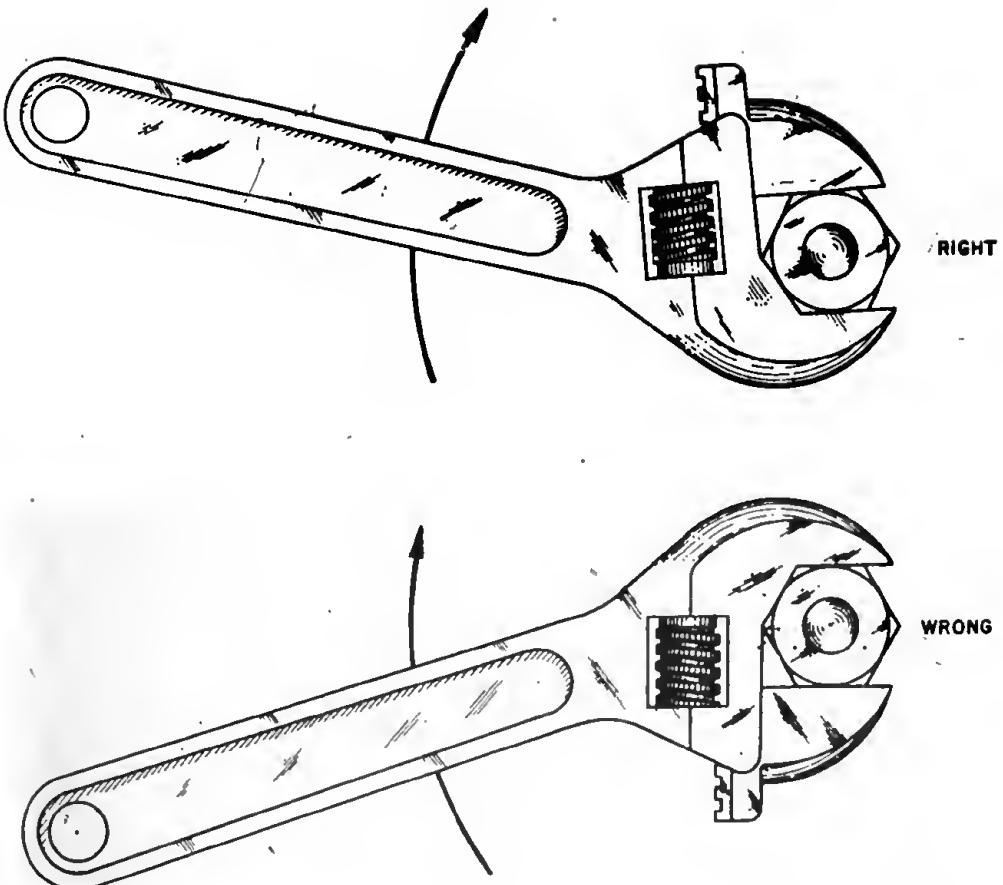


Figure 12. Right and wrang way to pull an adjustable-jaw wrench.

sively dirty or greasy. They should always be wiped off before being returned to the tool kit. Dirt should not be allowed to accumulate in the bottom of the tool kit; this is especially likely to happen in sandy areas. The proper type of wrench for the job at hand should always be used. The mechanic should be sure the wrench being used fits perfectly.

3. Pliers

a. GENERAL. Pliers are used when the grip of the hand alone is not sufficient to do the job and when holding or light cutting is to be done. They are made in a variety of shapes and sizes. The four most common types are listed as follows:

b. TYPES. (1) *Diagonal-cutting pliers* are used to cut safety wire, remove cotter pins, and do similar work.

(2) *Long-nose pliers* are used to reach where the fingers alone cannot, and to bend small pieces of metal.

(3) *Slip-joint pliers* are used to grip wires and bend small pieces of metal to the desired shape.

(4) *Water-pump pliers* are made with extra-long handles and therefore have a very powerful grip. (See fig. 13.)

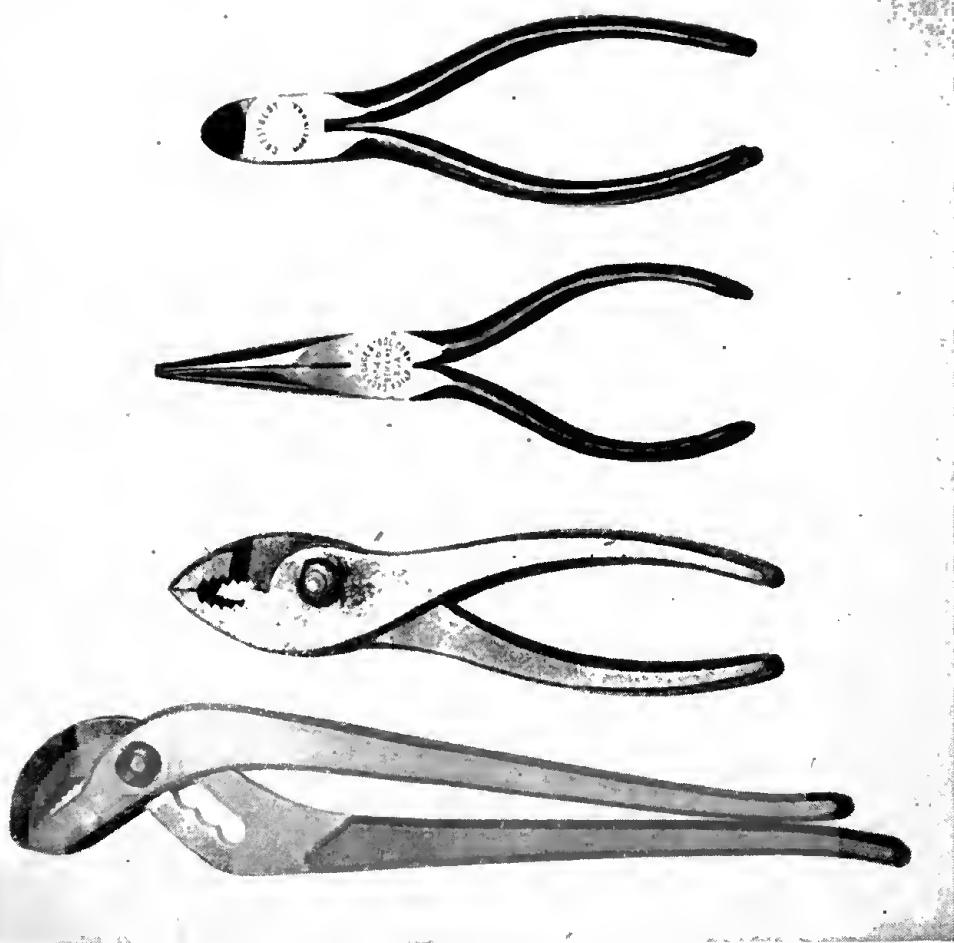


Figure 13. Types of pliers.

c. SELECTION AND USE. There is a common tendency among inexperienced mechanics to use pliers as an all-purpose tool. Pliers are made to aid the mechanic when installing and removing safety wire and cotter pins, to hold materials which the hand alone is not strong enough to hold, and to hold materials which are hot, such as connections which are being soldered. They are not to be used as wrenches. If so used, they will unquestionably damage the material and may, if they slip, injure the mechanic. There is one exception to the foregoing statements. Water-pump pliers may be used to tighten or loosen large nuts, such as water-pump packing nuts.

4. Screw Drivers

a. GENERAL. Light fastenings in aircraft are commonly made with screws. The screw driver is the tool used on these fastenings. Screws are made with various-shaped recesses in the head, and the proper screw driver is necessary in each case.

b. TYPES. (1) The *common screw driver* is familiar to everyone.

It has a steel blade set in a handle of wood or plastic. The faces of the blade are almost parallel at the point. The size of the common screw driver is designated by the length of the shank and blade. (See fig. 14.)

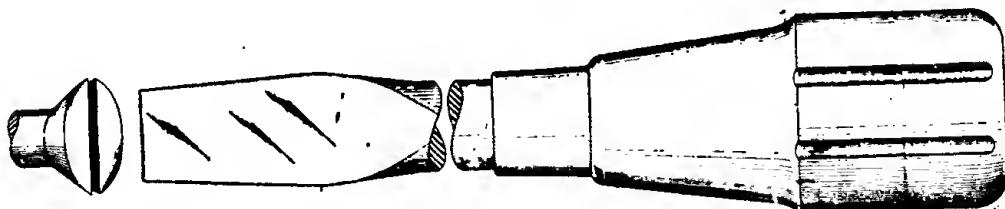


Figure 14. Common screw driver.

(2) The *crosspoint truncated screw driver* (fig. 15) is now standard. It is a compromise between the Reed and Prince and the Phillips types and will fit both types of screws.

(3) An *offset screw driver* is used to install or adjust screws which cannot be reached by a common screw driver. On each end it has a blade bent at right angles to the shank. The edge of one blade is parallel to the shank; the other is set at 90° to the shank. (See fig. 16.) It is not a convenient tool to use, but under certain conditions it is indispensable.

(4) A *nonmagnetic screw driver* is used to compensate a compass. It is shaped like a common screw driver, but is made with a brass blade so as to have no magnetic effect on the compass.

(5) The *spiral-ratchet screw driver* is used when a large number of screws must be installed or removed. It is so made that when the handle

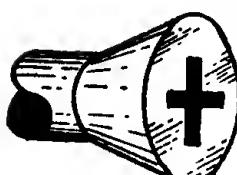
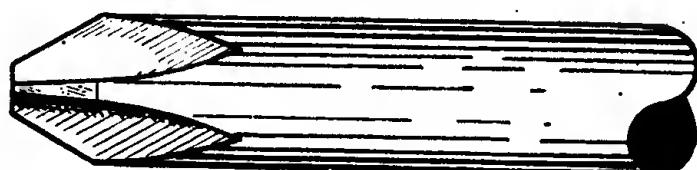
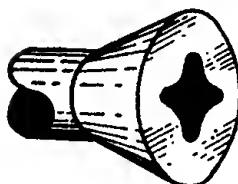


Figure 15. Crosspoint truncated screw driver.

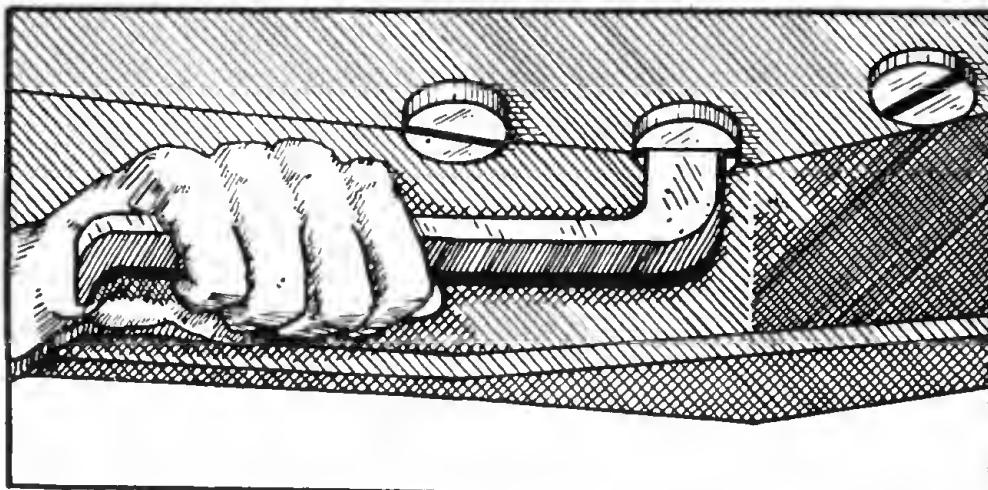


Figure 16. Offset screw driver and its application.

is pushed forward, the point is turned clockwise or counterclockwise, depending on how it is set. (See fig. 17.)

c. SELECTION AND USE. (1) Select the largest screw driver whose blade will make a good fit in the screw slot. This will prevent burring of the screw slot and damage to the blade and will reduce the force required to hold the blade in the slot.

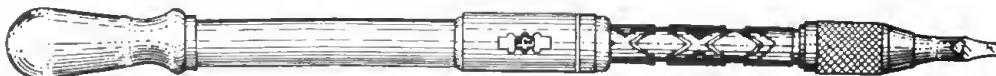
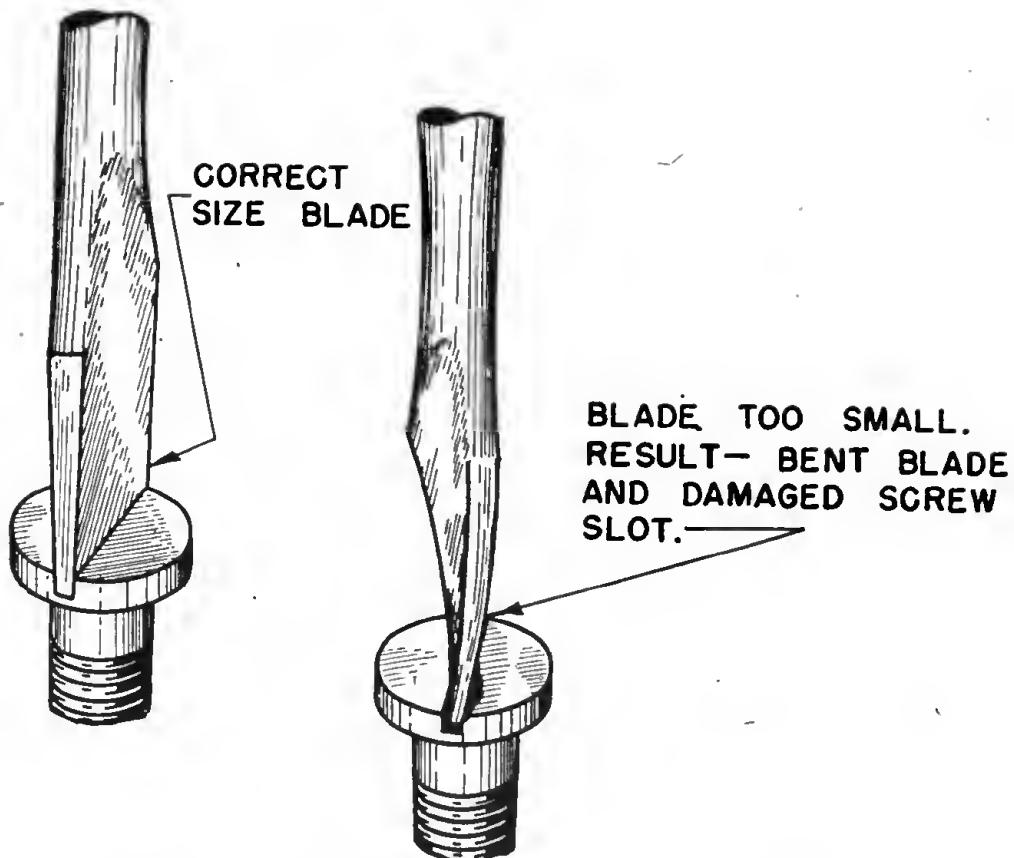


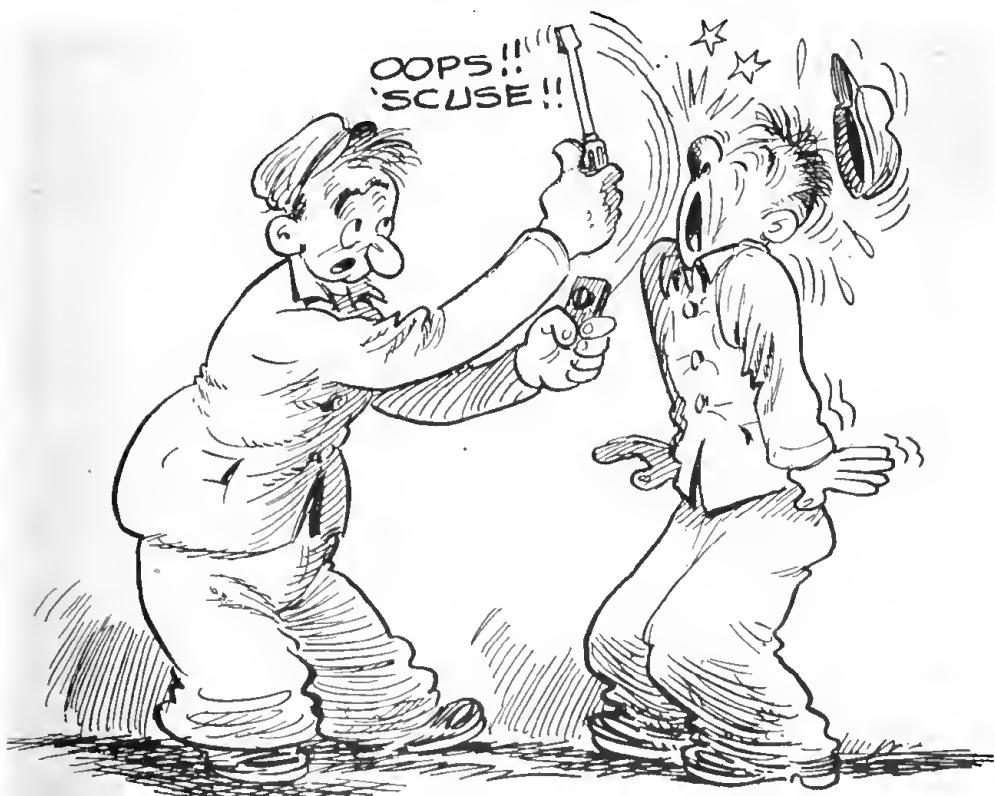
Figure 17. Spiral-ratchet screw driver.

(2) When using a screw driver, enough pressure should be applied to prevent the screw driver from climbing out of the slot. This is particularly important when using an offset screw driver. If the faces of the screw driver blade are not just about parallel, it will be very difficult to prevent it from climbing. Particularly tight screws can often be loosened by holding the screw driver firmly against the screw and turning the screw driver with a small wrench.

d. SAFETY PRECAUTIONS. Most accidents with screw drivers are caused by the blade slipping out of the screw slot. The mechanic should



Use a screw driver of correct blade thickness.



A slipping screw driver may hurt someone else—or you.

exercise sufficient care to prevent this and should avoid holding any part in the hand when using the screw driver on that part.

e. SHARPENING. A screw driver should never be ground to a chisel point. If necessary to grind a screw driver, best results can usually be obtained by using the side of the grinding wheel, applying only light pressure, and dipping the blade in water frequently to prevent drawing the temper from the blade. The point of the blade should not be ground so thin that it will bend easily. It should be left as thick as it was when new. It is almost impossible to recondition a crosspoint truncated screw driver with a wide grinding wheel. If it is necessary to use a wide wheel, it should first be dressed until the edges are almost square.

5. Hammers

a. TYPES. Hammers used by airplane mechanics are classified as ball-peen, brass, mallet, plastic, and sledge (striking hammer). (See fig. 18.)

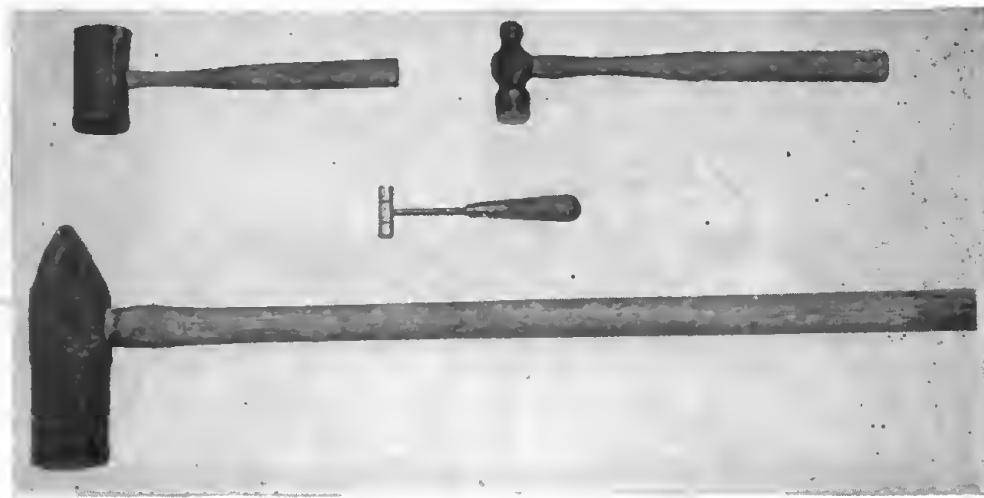


Figure 18. Hammers.

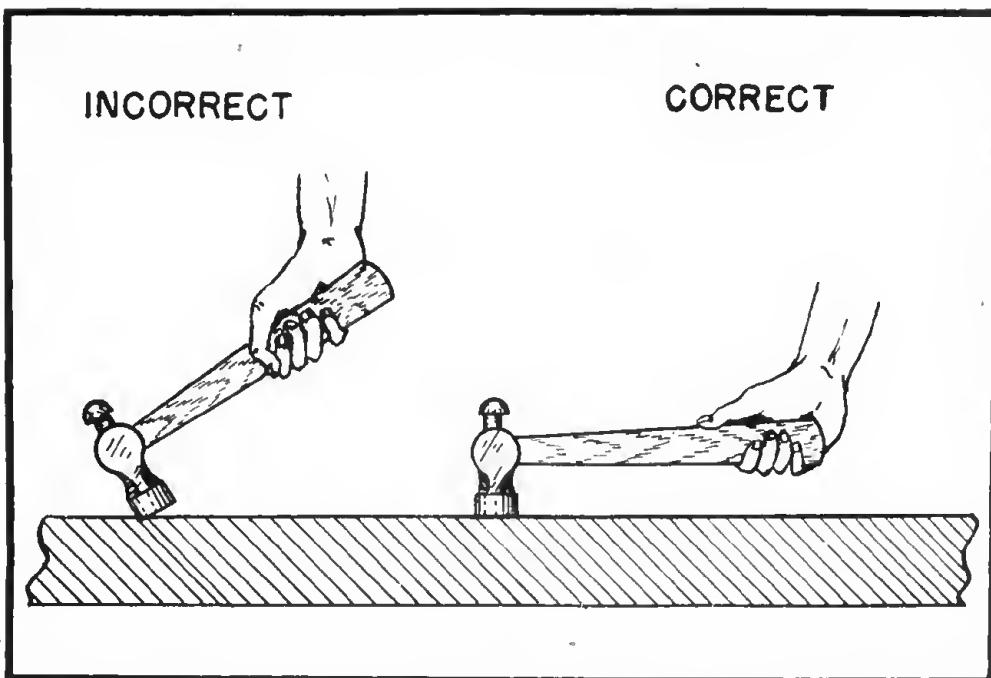
(1) The *ball-peen (machinist's) hammer* is the one used most often, and is usually a 12-ounce hammer, although a 6-ounce for light work and a 16-ounce hammer for heavy work are available.

(2) A *4- or 5-ounce brass hammer* is usually used for driving and setting cotter pins and other light operations. The brass head helps prevent marring the surface on which it is used. Heavier hammers of this type are also available.

(3) A *rawhide mallet* is used for working soft materials which would be damaged by the hard face of a hammer. The mallet consists of a tightly rolled rawhide head on a wooden handle.

(4) The *plastic-tip hammer* is also used for working with materials which are soft enough to be damaged by a harder hammer.

(5) A *sledge or striking hammer* is not properly a tool of airplane maintenance, but is used by an airplane mechanic for setting mooring pins



Grip the handle close to the end—this makes it easier to keep the head in upright position and, because of greater leverage, makes the blow more effective.



Always be sure that hammer handle fits hammer head tightly.

and other similar jobs. Sledges vary in weight from 4 to 20 pounds and have handles 30 to 36 inches long.

b. USE AND CARE. Practice is the only way in which a mechanic learns to use a hammer properly. However, the correct grip is an aid to a hammer's correct use. The handle should be held near the end with the fingers underneath and the thumb along the top or side. The thumb should always rest on the handle itself, never on the fingers. Glancing of the hammer off the work is usually caused by grease or oil on the face of the hammer. When glancing occurs, the face should be wiped off with a rag and then rubbed briskly with coarse sandpaper or emery cloth. Never use a hammer with a loose head or a cracked handle. It is dangerous to both material and personnel. If the head becomes loose, it can be tightened by driving in the wedge found in the end of the handle flush with the head. If the head begins to work off the handle, it can be set back to the proper position by striking the butt of the handle against a solid object such as a work bench. After the head has been moved back to its correct position, it should be tightened by driving in the wedge. Most accidents with hammers are caused by a loose head or a slippery handle. The mechanic should pay particular attention to these dangers when using a hammer.

SECTION III

SPECIAL AIRCRAFT WRENCHES AND TOOLS

6. General

On many parts of an airplane, standard wrenches cannot be used because of the shape or location of the part. For assembly and disassembly of these parts special wrenches had to be designed. No attempt will be made in this manual to include all the special wrenches the mechanic may use on the line, since new ones are constantly being devised. However, a special wrench differs from a standard wrench in shape only, and as the same general rules of use apply, the careful mechanic will have no trouble with it. A few special wrenches are described here so that the student will have some idea of what they are like.

7. Special Aircraft Engine Tools

a. GENERAL. Aircraft engines require more special wrenches than any other part of the airplane. Usually the kit furnished by the manufacturer includes the special wrenches needed for work on the engine. Such a kit would include some of the following wrenches.

b. TORQUE WRENCH. (1) A torque wrench is similar in operation to the ratchet handle of a socket wrench. It is made with a strong spring connection between the handle and the socket attachment. As the handle is pulled, the spring bends. The amount of bend is proportional to the torque applied. A gauge, located on the wrench handle, registers the amount of torque. The gauge is calibrated in inch-pounds. Some of the gauges have a floating pointer which is moved by the gauge pointer but the floating pointer remains at the point of maximum torque until set back to zero by the mechanic. Torque wrenches are usually manufactured to register a maximum of 250 or 3,500 inch-pounds. (See fig. 19.)

(2) A torque wrench enables a mechanic to tighten a nut with exactly the proper amount of torque. If a nut is left too loose, it does not hold securely. If it is tightened too tight, it may pull the bolt in two, strip the threads, or put an unnecessary and possibly dangerous strain on the members being held together. If a set of nuts (such as those which hold on a cylinder head) are not all tightened with the same torque, internal stresses will be set up in the cylinder head. These stresses may cause eventual failure of the cylinder head. Check after check has shown that structural failure and rapid wear have been caused by improper tightening of nuts and bolts.

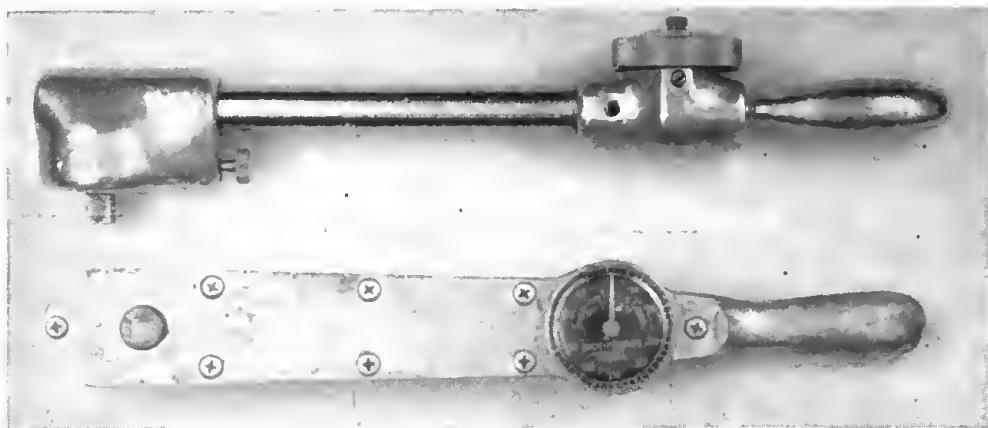


Figure 19. Torque wrenches.

(3) In assembly plants, depots, and subdepots, the torque wrench is a familiar tool. The line mechanic does not ordinarily use one because his work does not usually include work on which a torque wrench is essential. The mechanic should, however, consider proper torque whenever he works on the airplane. This is especially true when he is using an adjustable-jaw or socket wrench on small nuts and bolts, as the length of the handle makes it easy to apply too much torque.

c. PALNUT WRENCH. A palnut wrench is a thin, short-handled box-end wrench. It has a restraining plate on one side which prevents it from passing completely over the palnut. It is used to tighten and loosen palnuts but is not strong enough to be used on ordinary nuts and bolts. An ordinary wrench could be used for this purpose but would take more time since it has no restraining plate to prevent it from sliding past the palnut. (See fig. 20.)

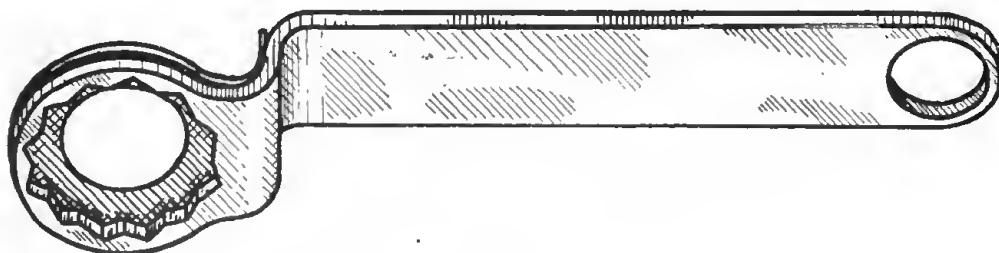


Figure 20. Palnut wrench.

d. STUD WRENCHES. (1) A stud-removing wrench has a recess for a socket handle, a hole through which the stud fits, and an off-center, hard-steel, milled-edge wheel. (See fig. 21.) It is used to remove stud bolts. The wrench is placed on the stud. The off-center wheel is held against the stud on the proper side and torque is applied by means of a socket handle. The off-center wheel binds against the stud and the stud is removed. (See fig. 22.)

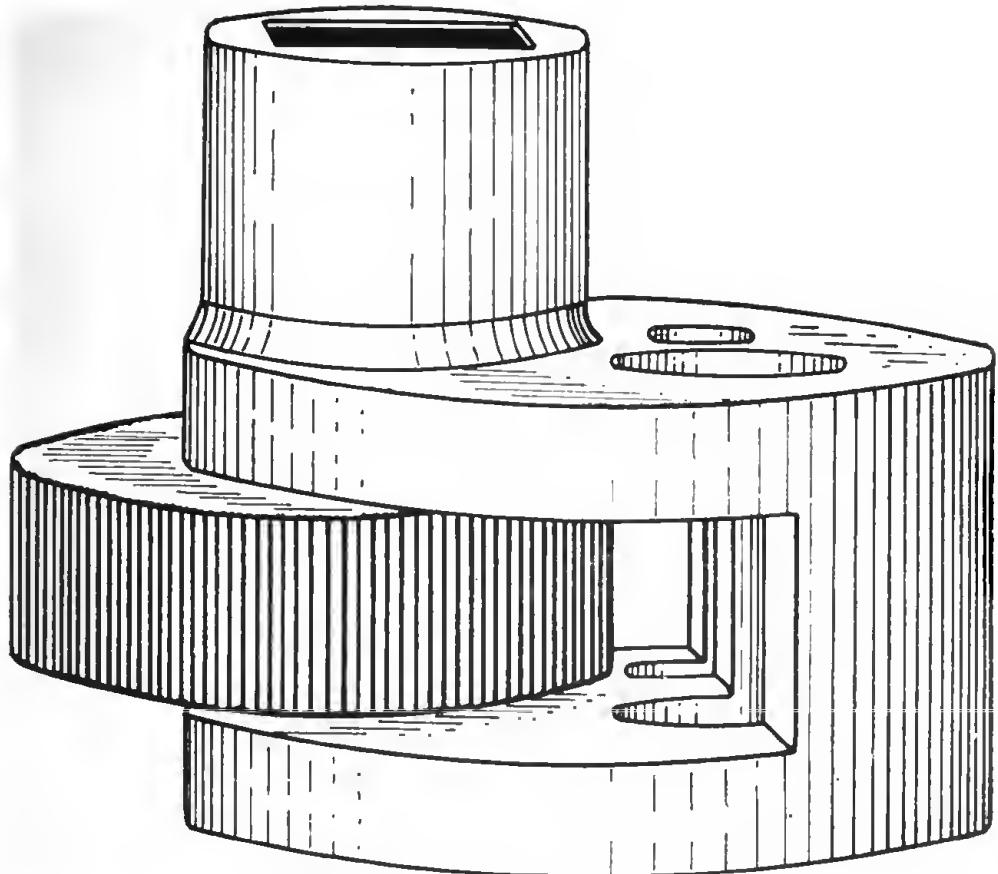


Figure 21. Stud-removing wrench.

(2) A stud-installing wrench consists of a head tapped to fit the fine threads of the stud bolt, and a shaft machined to fit a socket handle on one end, having coarse threads which screw into the head of the wrench on the other. A recess is machined in the head, leaving an opening of about 90° . A pin is driven through this recess into the shaft. Therefore the head of the wrench can be turned only 90° on the shaft. Turning the head 90° gives it a slight longitudinal movement since it is threaded on the shaft. (See fig. 23.) To install a stud, it is first screwed into the head of the wrench until it strikes the end of the shaft. The other end of the stud is then screwed into place, using a socket handle to turn the wrench. When the stud is tightened with the proper torque the shaft of the wrench is turned counterclockwise. As the shaft turns 90° in relation to the head it is freed from the end of the stud. The wrench can then be easily removed.

(3) In an emergency, studs may be installed or removed by threading two nuts on the fine threads of the stud and binding one against the other. The stud can then be removed or installed by using these nuts as though they were the head of a bolt. The nuts may be removed from the stud by holding one and loosening the other. Two wrenches would, of course, be necessary. (See fig. 24.)

e. GEAR AND BEARING PULLERS. (1) Gear and bearing pullers are made in a variety of shapes and sizes. One usually consists of a collar which has a threaded hole in the center, two or three L-shaped bars pinned to the outside of it, and a bolt which fits the threaded hole of the

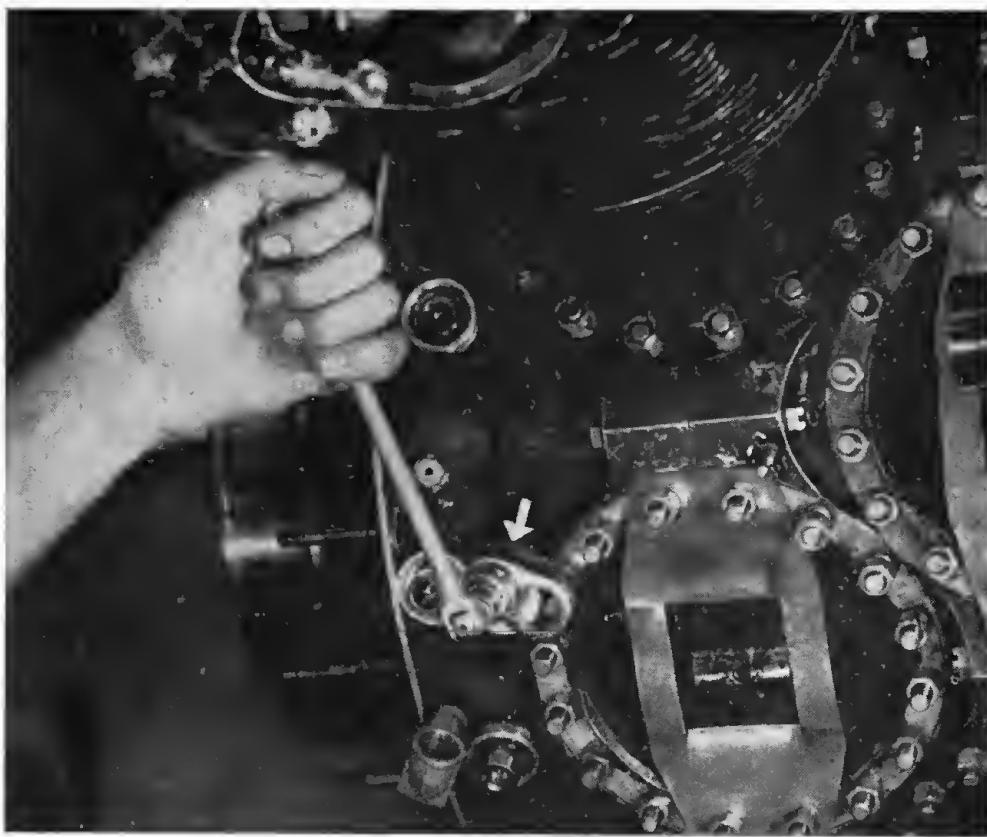


Figure 22. Stud-removing wrench in use.

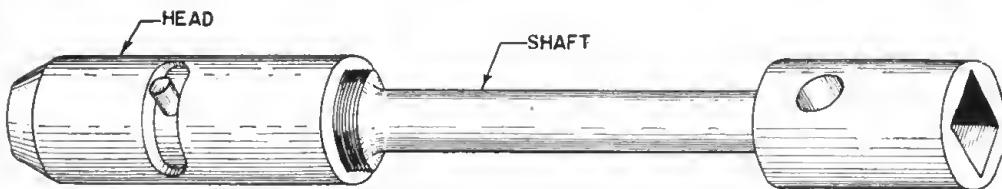


Figure 23. Stud-installing wrench.

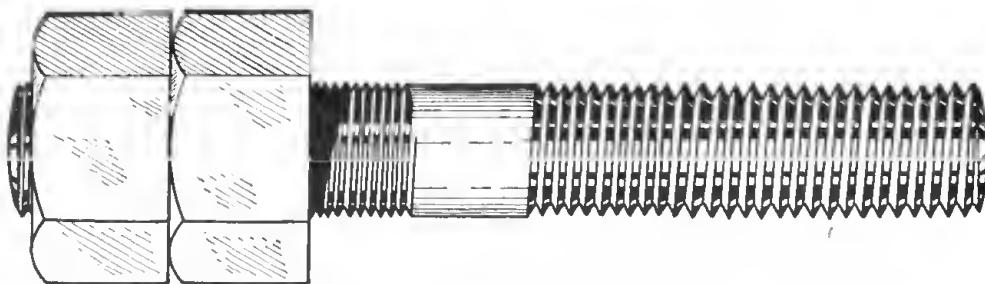


Figure 24. Two nuts on a stud—emergency method of tightening or loosening a stud.

collar. The end of the bolt may be conical, semispherical, or flat, depending on the shape of the recess in the end of the shaft. (See fig. 25.)



Figure 25. Gear and bearing pullers.

(2) Gears, collars, ball bearings, and similar parts sometimes bind on the shaft. When they do, they may be easily removed by the use of a gear puller. The ends of the L-shaped bars are first placed around the gear to be removed and then the bolt is screwed down until it bears against the shaft. As the bolt is tightened further, the gear is pulled off the shaft. If the gear seems to be stuck so that the gear puller cannot move it, striking the head of the bolt of the gear puller will often jar it loose. When removing ball bearings, the force must be against the inner race only, or damage to the bearing will result.

f. OIL-PUMP PULLER. (1) An oil-pump puller is a shaft with a firmly attached crosshead on one end, a nut on the other, and a loose-fitting piece of metal free to slide on the shaft. It resembles the letter "I" in shape. The crosshead has several holes or a slot on each side. (See fig. 26.)

(2) Oil pumps on many types of airplane engines fit tightly and have no spot at which the mechanic can grip them to remove them. Removal of these pumps is made easy with an oil-pump puller.

(3) Two bolts are inserted through the head of the puller and tightened into two threaded holes in the oil pump. The sliding weight is then used to hammer against the nut on the end of the shaft, pulling the oil pump loose.

g. CYLINDER STUD-NUT WRENCH. A cylinder stud-nut wrench is a socket wrench with one side machined away and an offset drive. It may be either left- or right-handed. (See fig. 27.) Ordinary wrenches cannot be used on cylinder-head nuts because of the inaccessibility of the

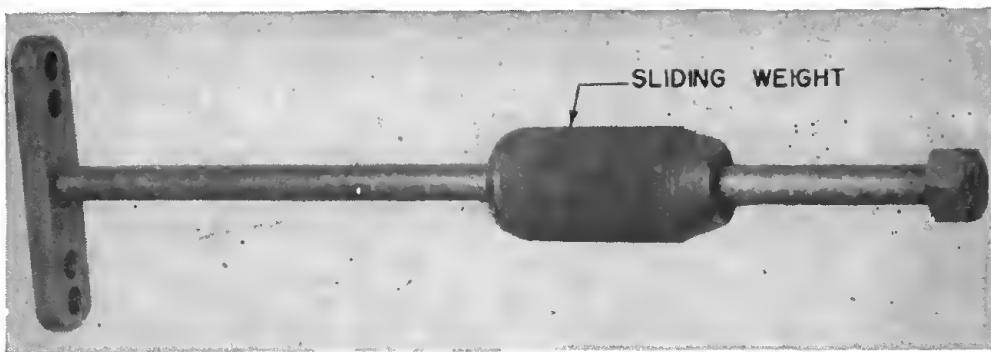


Figure 26. Oil-pump puller.

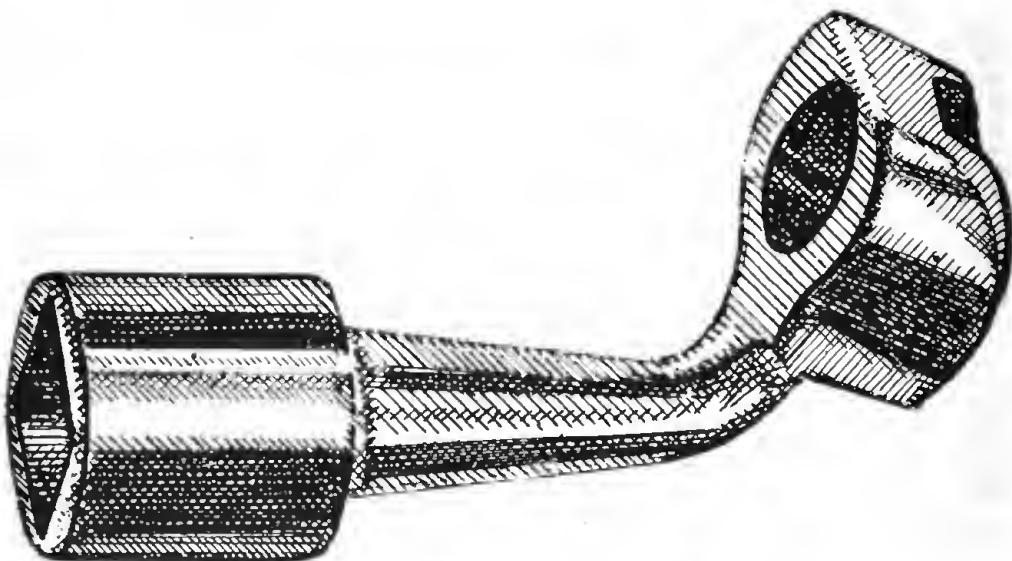


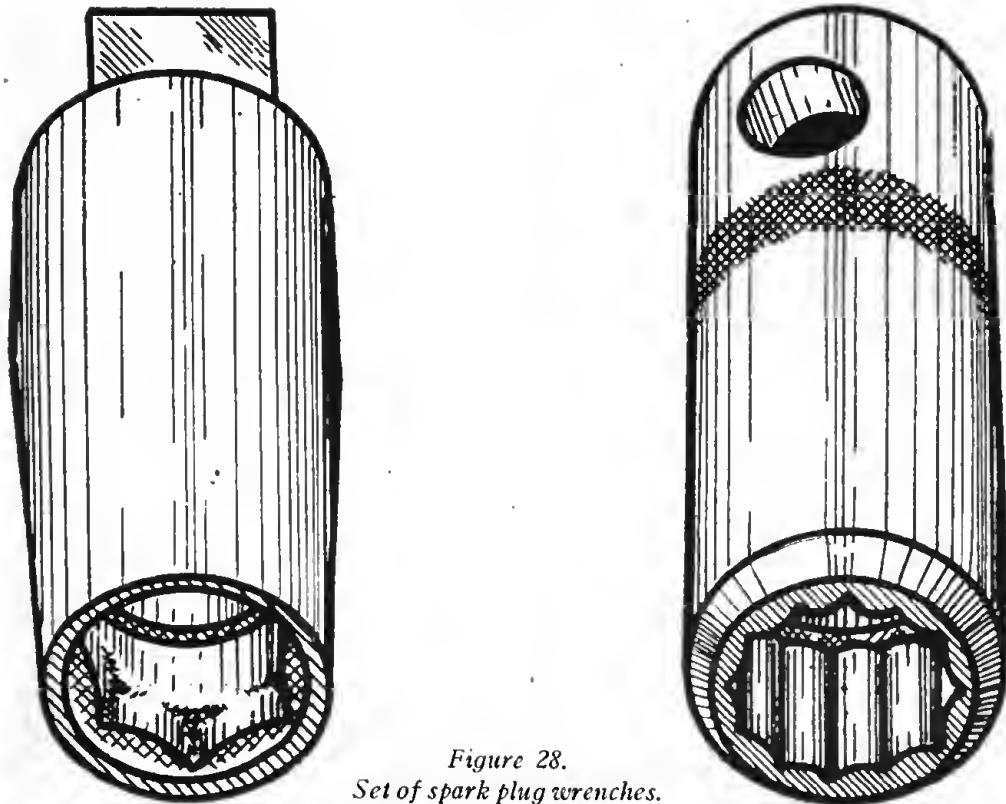
Figure 27. Cylinder stud nut wrench.

nut. Therefore, the cylinder stud-nut wrench had to be designed. Its use is similar to any other socket wrench.

h. SPARK-PLUG WRENCH. The spark-plug wrench is similar to a socket wrench but is much longer. The upper part of a spark plug protrudes so far that an ordinary socket does not reach to the hexagonal-shaped part of the spark plug. The spark-plug wrench is made deep enough that it will fit over the upper part of the spark plug and grip the hexagonal band near the base. These wrenches are made in various sizes, one of which fits every size of spark plug. They will fit standard socket handles and are used as any other socket wrench is used. Figure 28 shows a set of spark-plug wrenches.

i. SPARK-PLUG ELBOW WRENCH. (1) A spark-plug elbow wrench is shaped like an open-end wrench with the handle at 90° to the head of the wrench. The handle is fastened permanently to the wrench and may be either long or short. (See fig. 29.)

(2) This wrench is used to fasten the lead wires to the spark plugs. An ordinary open-end wrench cannot always be used because of lack



*Figure 28.
Set of spark plug wrenches.*

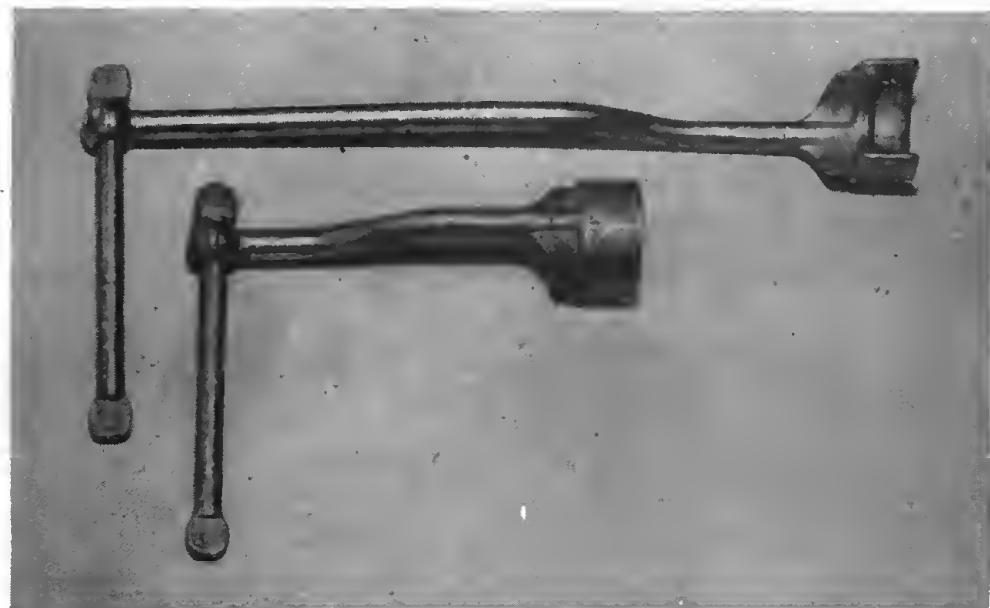


Figure 29. Spark-plug elbow wrenches.

of room. Both the long and short handles are necessary in order to be able to reach the leads on all of the spark plugs.

j. VALVE-TAPPET-ADJUSTING SCREW AND NUT WRENCH. (1) This wrench has two handles. One is fastened to a socket which will fit the adjusting-screw locknut. The other is fastened to a shaft which passes through the center of the socket and fits the adjusting screw itself. (See fig. 30.)

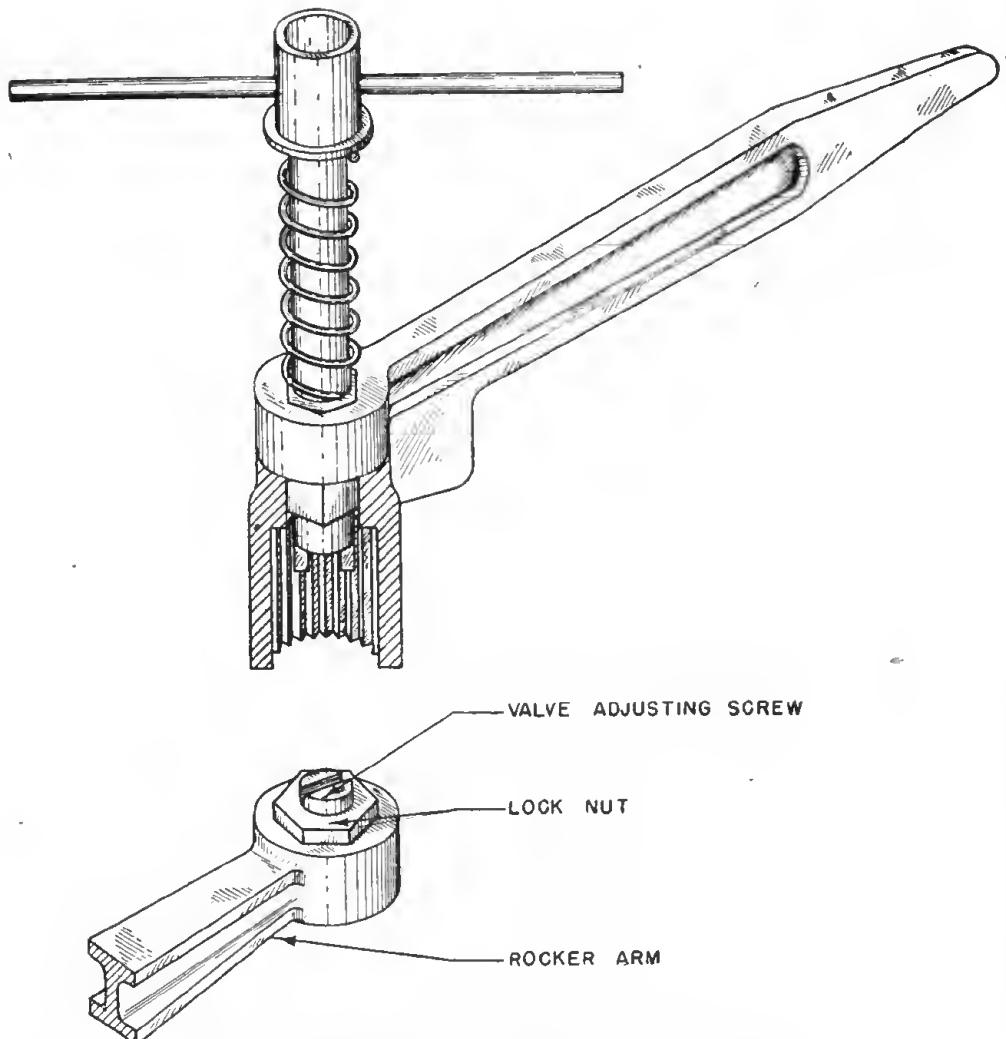


Figure 30. Valve-adjusting screw and nut wrench.

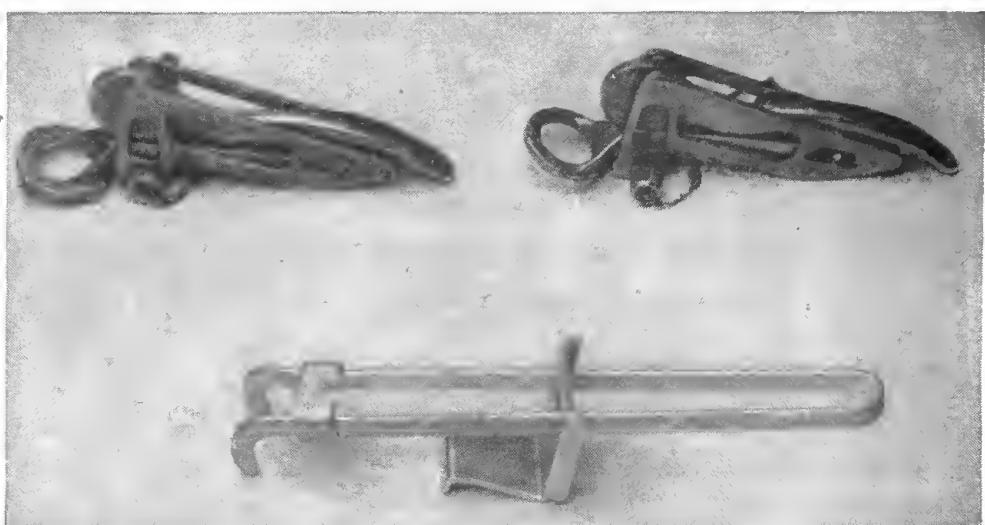


Figure 31. Valve-spring depressors.

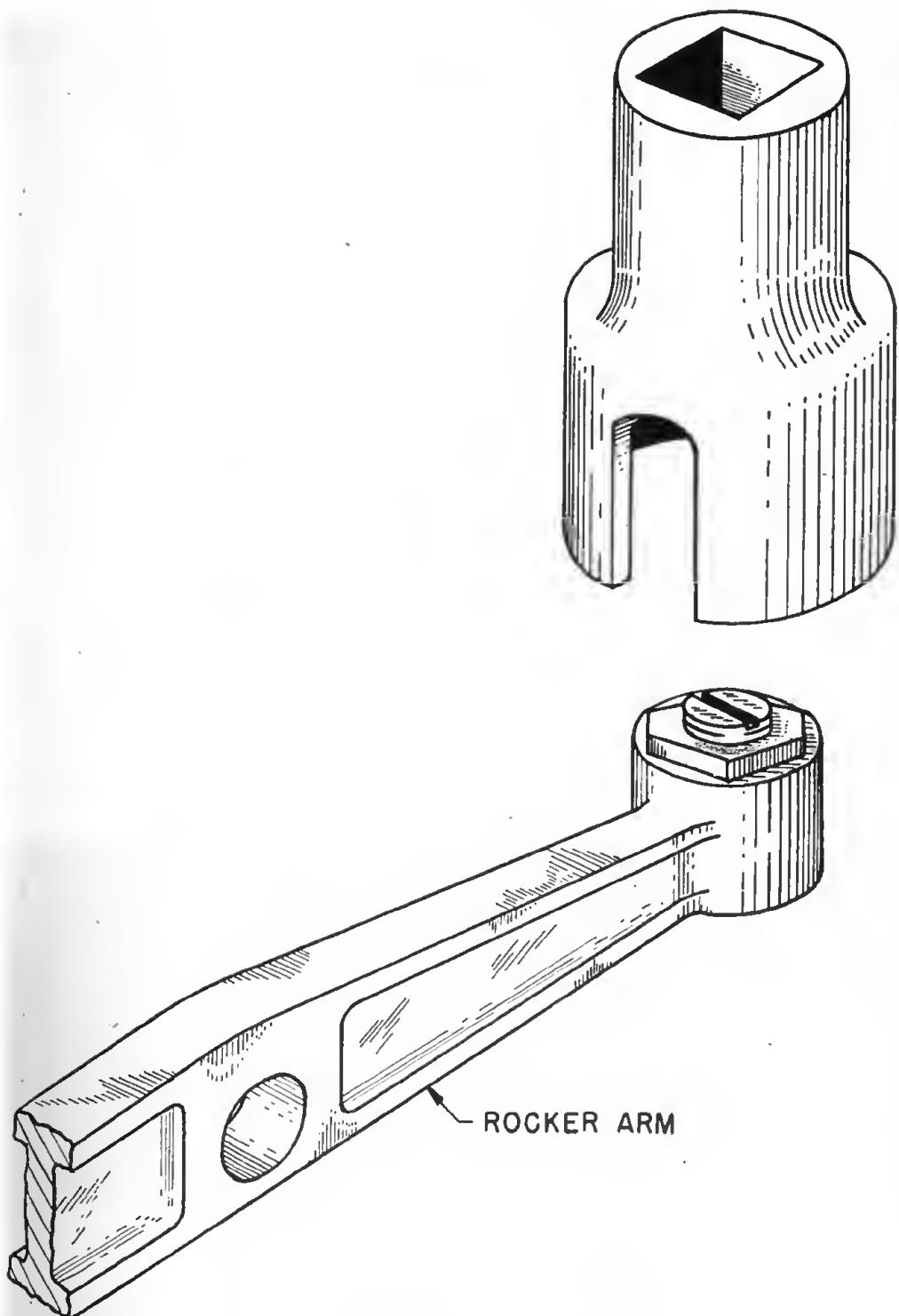


Figure 32. Valve-spring depressors.

(2) The wrench is used when adjusting valve clearances. The wrench is fitted over the adjusting screw and the locknut is loosened. The handle which turns the locknut is then held stationary and the adjusting-screw handle turned clockwise or counterclockwise to bring the valve clearance within the specified tolerance. The adjusting-screw handle is then held stationary and the locknut tightened.

k. VALVE-SPRING DEPRESSOR. (1) There are several types of valve-spring depressors (also called valve-spring compressors). Three of the different types are shown in figure 31. They are used to compress the valve springs when inserting or removing the valve-spring split locks.

(2) Valve springs are very strong. If the depressor slips while it is being used, a painful injury is likely to result. Therefore, the mechanic should make certain the valve-spring depressor is fitted properly when he is using it.

l. ROCKER-ARM DEPRESSOR. (1) The rocker-arm depressor is shaped like a large socket with a notch milled in one side. The notch fits over the rocker arm. The depressor is used to depress the valve spring and rocker arm when removing a push rod and push-rod cover. (See fig. 32.)

(2) The rocker-arm depressor is placed over the rocker arm and a long extension bar is inserted into the hole in the top of the rocker-arm depressor. Pressure is maintained on the bar toward the rocker arm to prevent the depressor from slipping off. The extension bar is pulled to the side and down, freeing the push rod and cover so that they may be removed. (See fig. 33.)

m. PUSH-ROD COVER NUT WRENCH. The push-rod cover nut wrench is semicircular in shape, having a lip on the outside with a square hole in

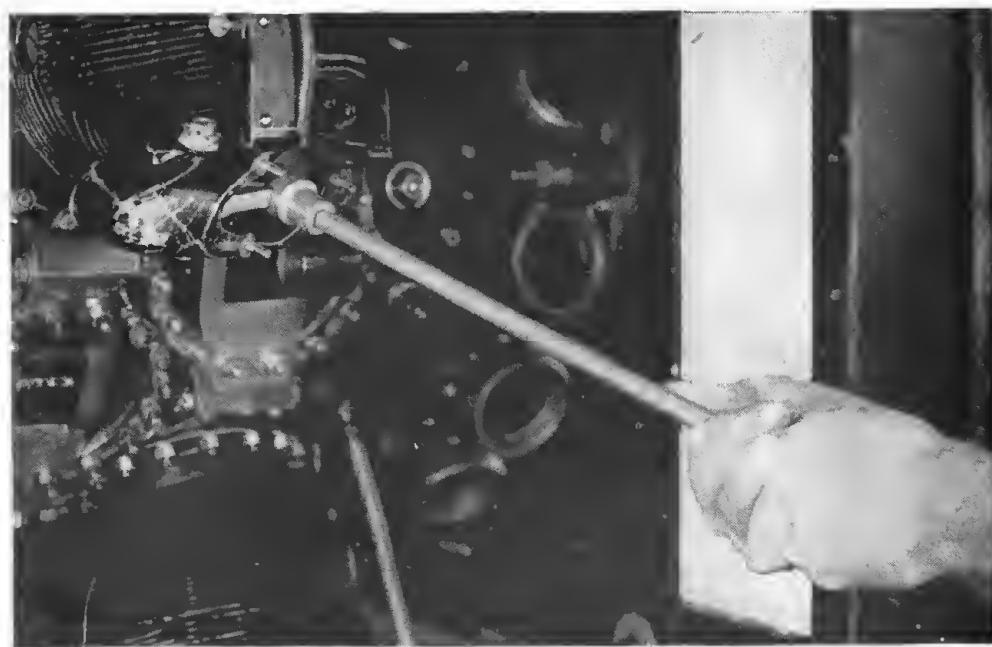


Figure 33. Rocker-arm depressor in use.

it, and lugs on the semicircular part to fit the nut which holds the push-rod cover in place. It is used to loosen or tighten the push-rod cover nuts. In operation, it is similar to a socket wrench. (See fig. 34.)

n. STARTER AND GENERATOR STUD-NUT WRENCH. (1) This is a small wrench about 2 inches long. One end is open and fits the attaching nuts of the starter and generator. The other end has a square hole for an extension bar. (See fig. 35.)

(2) An open-end wrench will fit the attaching bolts on a starter and generator, but cannot be used because the magnetos are in the way. With the starter and generator wrench, the extension bar allows the handle to reach behind the accessories where its swing is not hindered.

o. HOSE-CLAMP WRENCH. (1) A hose-clamp wrench consists of a fitting for the hose-clamp thumb screw fastened on one end of a piece of wire cable through a universal joint, and a handle on the other end. It is about 20 inches long. (See fig. 36.)

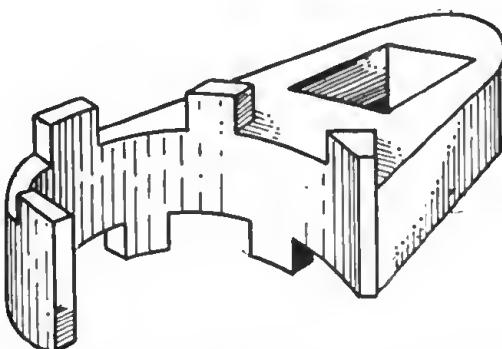


Figure 34. Push-rod cover-nut wrench.

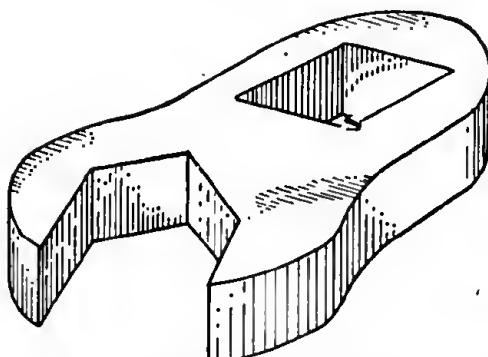


Figure 35. Starter and generator stud-nut wrench.

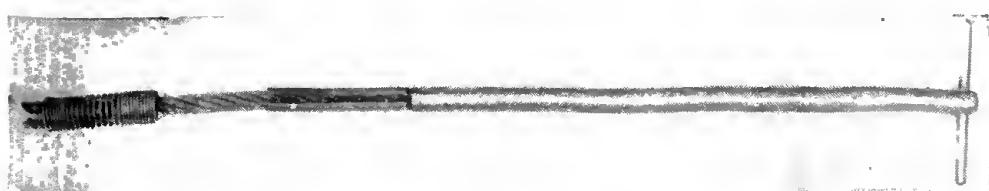


Figure 36. Hose-clamp wrench.

(2) It is used to tighten and loosen hose-clamp connections. Its length and flexibility make it possible to tighten fittings that would otherwise be difficult to reach. The cable is used as an indicator of the torque applied. As a fitting is tightened, the cable strands will spread apart when the applied torque is 20 to 25 inch-pounds. This is the proper amount of torque for hose-clamp connections. (This value may be obtained approximately by tightening the clamp-screw finger tight, then turning it one to one and one-half turns for nonself-sealing hose and two to two and one-half turns for aromatic-resistant, self-sealing hose.)

p. OIL-FLANGE WRENCH. The oil-flange wrench has a square hole for an extension bar and two prongs which fit the oil-flange nuts. It is used to remove and install an oil flange. (See fig. 37.)

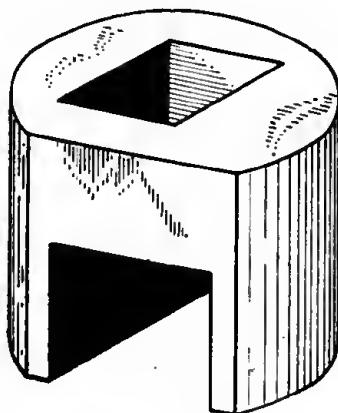


Figure 37. Oil-flange wrench.

q. OIL-SUMP STUD WRENCH. One end of this wrench is machined to fit the inside of the oil-sump plug. The other end contains a square hole for an extension bar. It is used to remove the oil-sump plug. In use it is similar to an ordinary socket except that it fits the inside of the plug instead of the outside. (See fig. 38.)

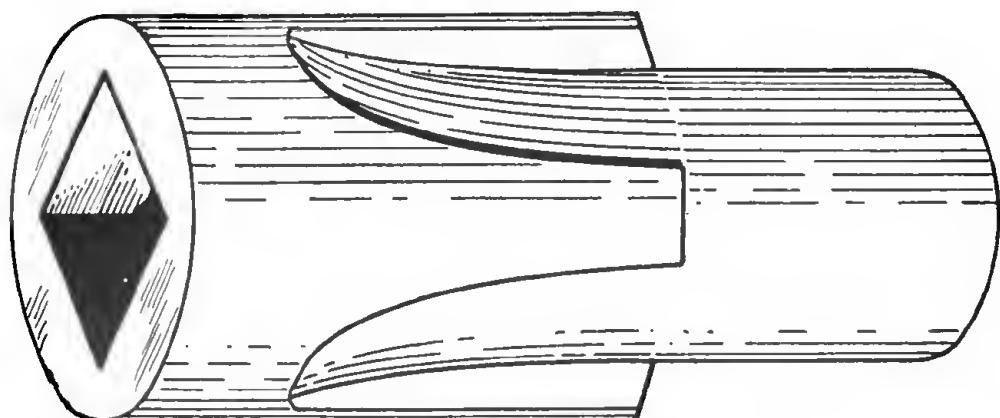


Figure 38. Oil-sump stud wrench.

8. Special Aircraft-propeller Tools

a. SPANNER WRENCHES. (1) A spanner wrench has a semicircular head on a handle. The radius of the head depends upon the part the wrench is made to fit. There are lugs or pins on the head to provide a gripping surface. A solid spanner wrench is made to fit some particular piece of equipment. An adjustable spanner wrench has a pivoted head and may be used to fit nuts of different sizes. Several different spanner wrenches are shown in figure 39.

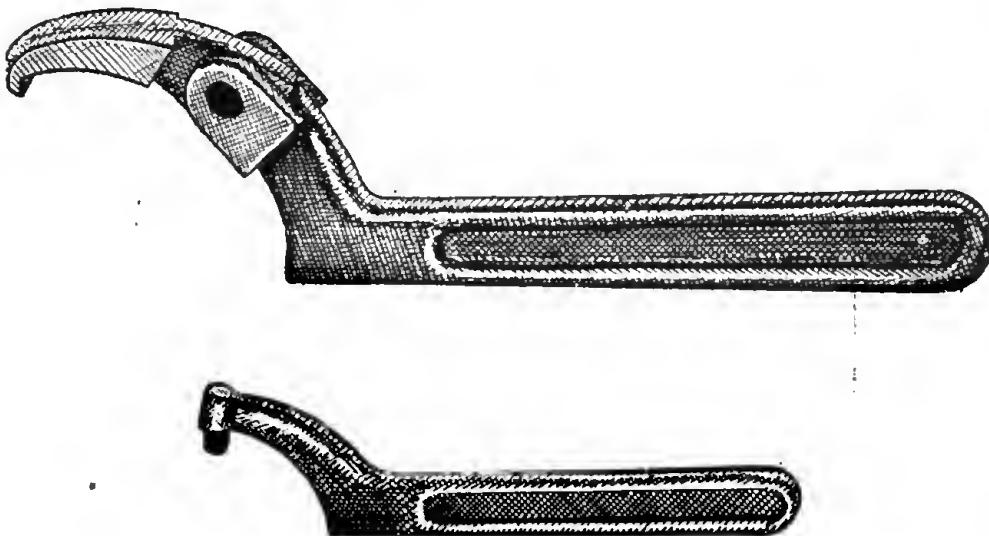


Figure 39. Spanner wrenches.

(2) Spanner wrenches are used to loosen and tighten nuts (such as blade-retaining nuts) that are circular on the outer surfaces. There are notches in the outer surface of the nut into which the lugs of the wrench fit. Spanner wrenches are used as any other wrench is used, but they have a greater tendency to slip off the nut. This should be guarded against by the mechanic.

b. PROPELLER PISTON-MOVING TOOL. (1) The propeller pitch-changing tool consists of a slightly tapered head mounted securely on a threaded shaft. A crank is provided which is threaded to fit the shaft. It also has a bearing plate which slides onto the shaft. (See fig. 40.)

(2) It is used to move the Hamilton hydromatic-propeller piston forward in the dome assembly when the dome is not installed in the hub. The shaft of the pitch-changing tool is inserted from the drive-gear end of the dome assembly, the bearing plate is slipped on the shaft and screwed into the dome, and the crank turned. As the crank is turned, the head of the tool is drawn forward, pulling the piston to its full-forward position. This changes the position of the piston in the dome assembly.

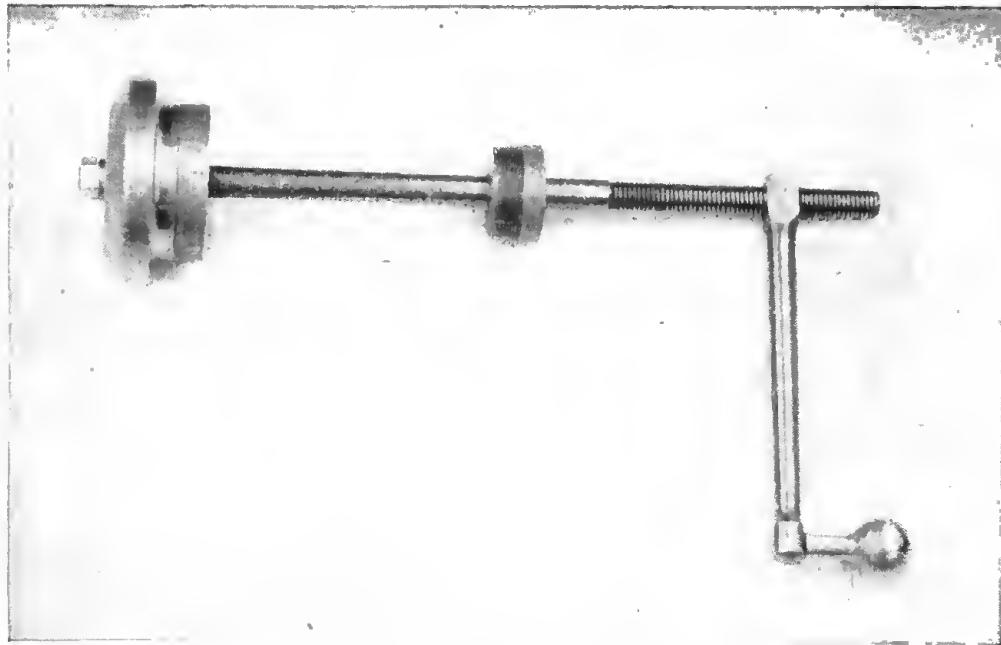


Figure 40. Propeller piston-moving tool.

c. PROPELLER-BLADE BEAM. This tool is usually made of wood. It is shaped like a paddle. There is a hole cut in the wide part to fit over the propeller blade. By slipping blade beams over two of the propeller blades and pulling on the end of the handle, the blade angle of the propeller is changed. It is usually used when the propeller is mounted on an airplane. (See fig. 41.)

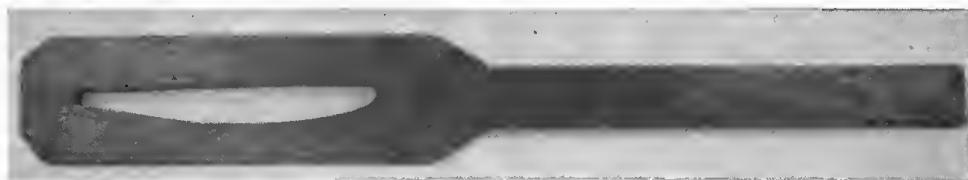


Figure 41. Propeller-blade beam.

d. PROTRACTOR ASSEMBLY. (1) This assembly (fig. 42) may be used to measure propeller-blade angle, control-surface movement, or any other angle. It consists of an aluminum frame in which a steel ring and a disk are mounted. Spirit levels are mounted on both the frame and the disk. Locks are provided for locking the ring to the frame or the disk. Scales are marked on the disk and the ring and the zeros of these scales provide reference marks between which the angle may be read. Hand-adjusting screws are provided so that the ring and the disk may be rotated in relation to the housing and to each other.

(2) To measure the upward throw of a control surface, first place the surface in neutral. After aligning the zeros on the ring-and-disk scales, lock the two together. Place the protractor in a vertical position

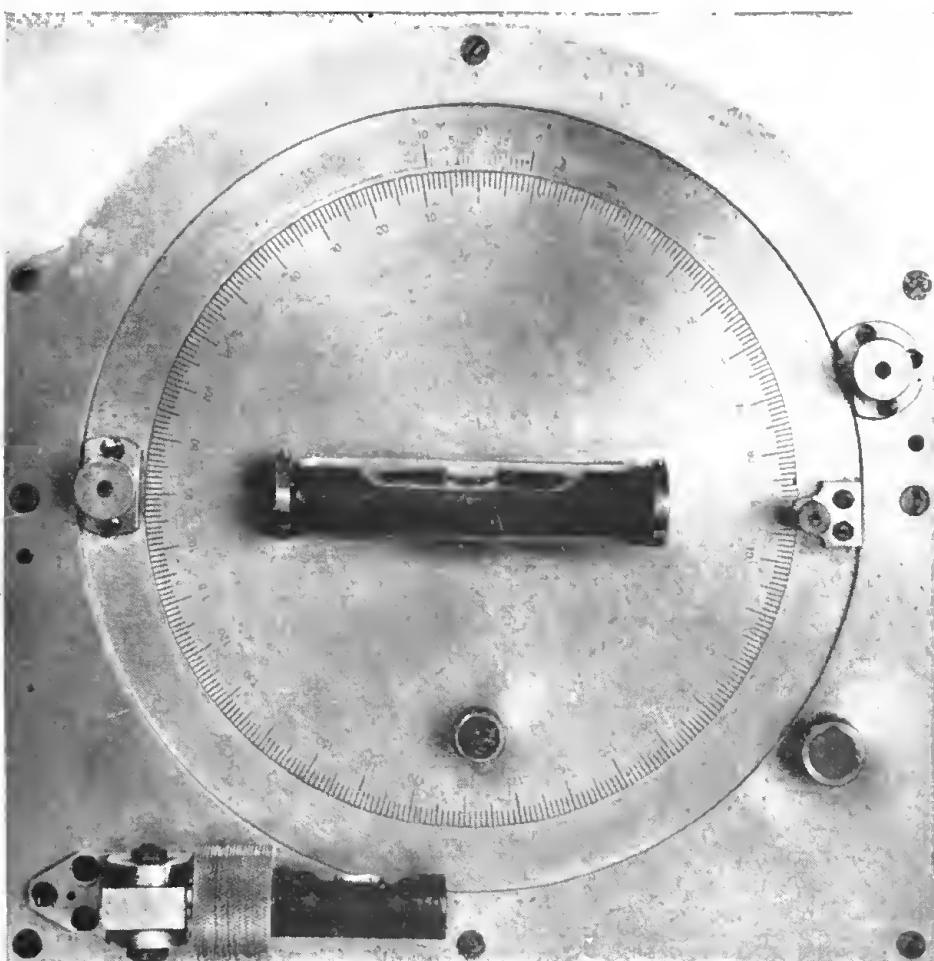
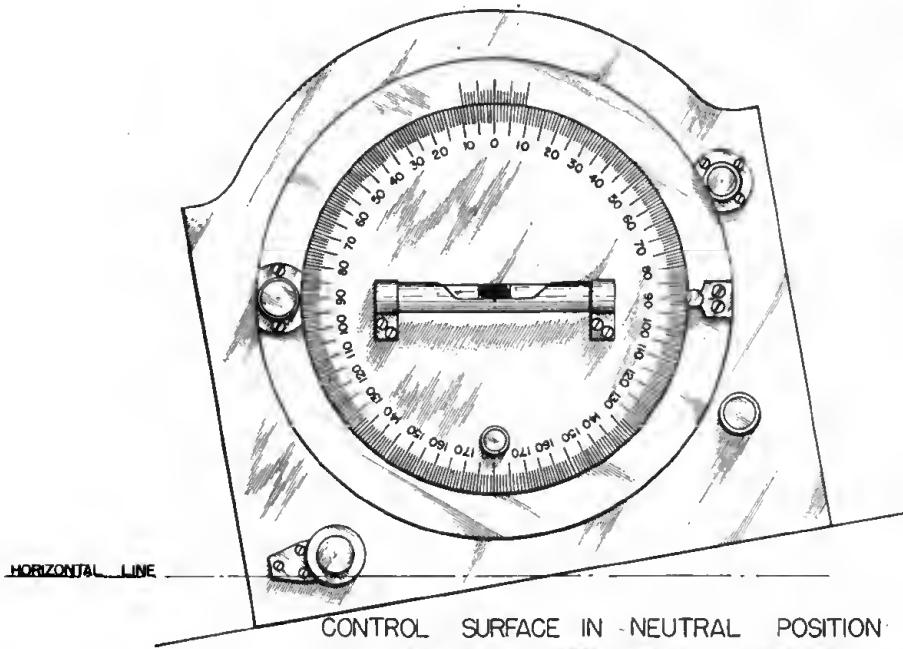


Figure 42. Protractor assembly.

on the control surface, release the ring-to-frame lock, and rotate the ring and disk until the spirit level on the disk is level. (See fig. 43 ①.) Next move the control surface to the up position and, after locking the ring-to-frame, place the assembly on the control surface in the same position as before. Rotate the disk until the disk spirit level is again level. (See fig. 43 ②.) The angle, in degrees, may then be read between the two zeros. Tents of a degree may be determined by finding which division of the ring scale comes closest to alignment with a division of the disk scale. Read tenths in the same direction degrees are read. The assembly should be handled carefully and kept in its case when not in use.

9. Miscellaneous Aircraft Tools

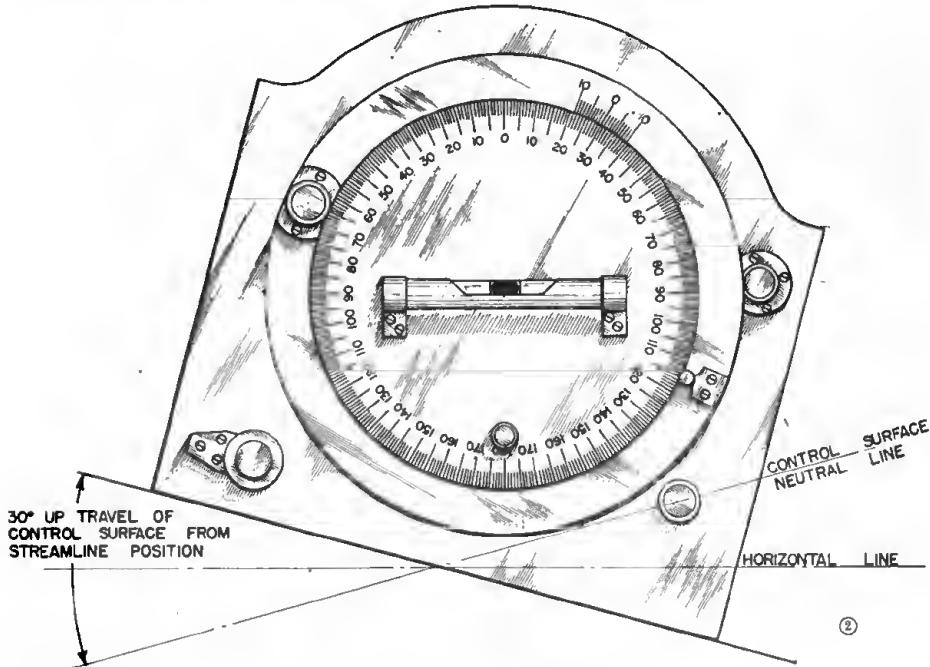
a. **TENSIOMETER.** (1) A tensiometer (fig. 44) consists of a flat spring with a roller on the bottom of each end. An adjustable clamp is located in the center. A pointer is riveted to one end of the spring. The pointer extends across the spring to a scale which is riveted on the other end. It is used to measure the tension of control cables and brace wires.



CONTROL SURFACE IN NEUTRAL POSITION

1. ALIGN CONTROL SURFACE IN NEUTRAL POSITION.
2. LOCK RING TO DISC AT ZERO BY DROPPING LOCK PIN IN DEEPEST SLOT.
3. PLACE PROTRACTOR APPROXIMATELY IN MIDDLE OF SURFACE NEXT TO RIB.
4. USING RING ADJUSTING SCREW, ALIGN BUBBLE IN LEVEL TO IT'S CENTER POSITION.
5. TURN LOCK FOR RING UNTIL IT IS FINGER TIGHT.

1. PLACE INSTRUMENT BACK ON CONTROL SURFACE IN THE SAME PLACE AS BEFORE.
2. HAVE SOMEONE IN COCKPIT MOVE CONTROL SURFACE TO FULL UP POSITION.
3. TURN DISC ADJUSTING SCREW UNTIL BUBBLE IN LEVEL IS CENTERED.
4. REMOVE INSTRUMENT FROM SURFACE AND READ THROW IN DEGREES.



CONTROL SURFACE IN FULL UP POSITION

Figure 43. Use of protractor assembly to measure aileron throw.

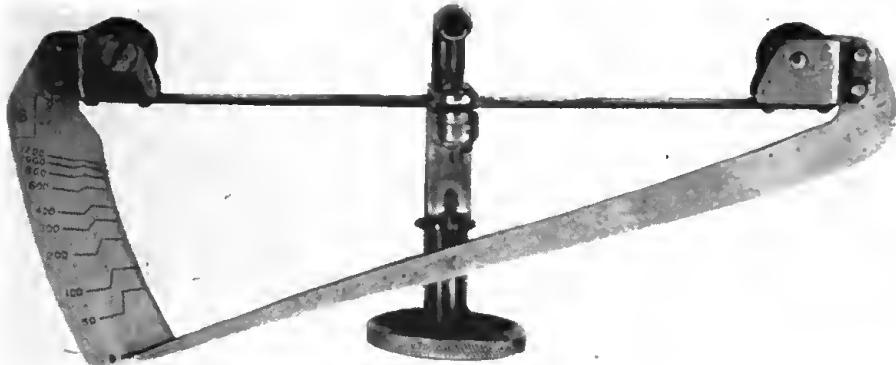


Figure 44. Tensiometer.

(2) Like any other measuring instrument, the tensiometer should be handled carefully. Rough treatment will cause it to lose its accuracy. To measure the tension on a control cable, the controls should first be locked in neutral. The tensiometer is then placed on the control cable with the two rollers on one side of the cable and the clamp on the other. The hand wheel is turned, drawing the clamp in until the cable touches the spring. The pointer will then indicate the cable tension on the gauge. (See fig. 45.)



Figure 45. Tensiometer in use.

(3) A new type of tensiometer is shown in figure 46. This instrument is also used to measure the tension of control cables and will do the job faster than the old type. It also has the advantage of retaining the reading until reset to zero by the mechanic. The arm on the right side

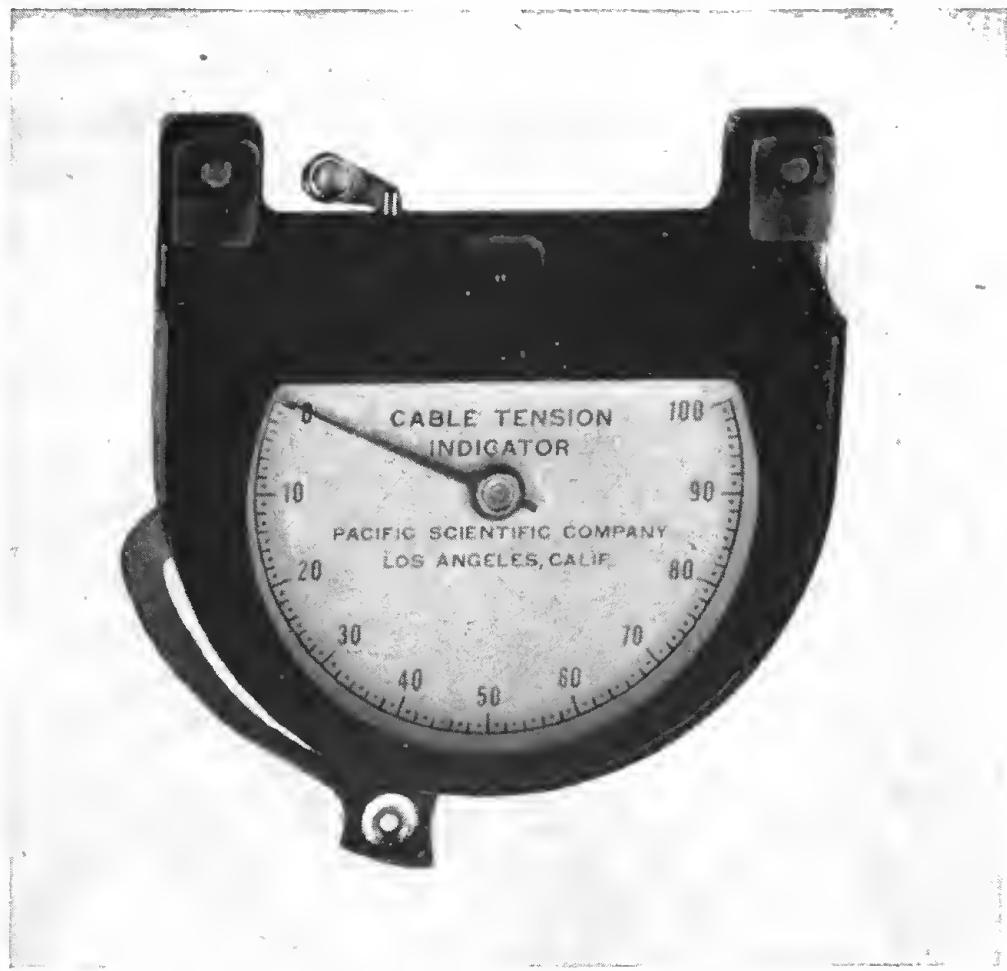


Figure 46. New type of tensiometer.

of this tensiometer may be easily pulled away from the case. This allows the center-bearing block to retract into the case so that a cable may be placed between the two outside and the center-bearing blocks. The arm on the side of the case is then pushed back against the case, forcing the center-bearing block against the cable. The recording mechanism is connected to the center block and will now give a reading. The gauge is graduated from 0 to 100. By referring to the reference chart (fig. 47) included with each instrument, the tension of the cable in pounds may be determined. For example, if the instrument reads 36 and the cable being tested is $\frac{1}{8}$ -inch cable, the tension is 60 pounds. This tensiometer may be removed from the cable and will still record the tension that was on the cable when tested. To reset the tensiometer to zero, the mechanic merely rotates a small lever on the base of the tensiometer with his finger.

b. TURNBUCKLE WRENCH. The turnbuckle wrench (fig. 48) is a short bar curved on each end to fit the body of a turnbuckle. Each curved surface has a short steel peg which fits into the hole in the center of the turnbuckle. It is used to adjust turnbuckles.

NO. 1			RIBER	NO. 2					
DIA.	$\frac{1}{16}$	$\frac{3}{32}$	$\frac{1}{8}$	TENSION LBS	$\frac{5}{32}$	$\frac{3}{16}$	TENSION LBS	$\frac{5}{32}$	$\frac{3}{16}$
12	15	19		30	12	18	260	73	90
16	20	25		40	16	23	270	75	92
20	25	31		50	20	28	280	77	94
24	30	36		60	24	32	290	79	96
29	35	42		70	27	36	300	80	98
33	40	47		80	30	40			
37	45	52		90	33	44			
41	49	57		100	36	48			
44	53	62		110	39	52			
48	57	66		120	42	55			
51	61	70		130	45	58			
54	64	74		140	48	61			
57	68	78		150	50	64			
60	71	82		160	53	67			
63	74	86		170	55	69			
66	77	89		180	58	72			
69	80	93		190	60	74			
71	83	96		200	62	77			
				210	64	79			
				220	66	81			
				230	68	84			
				NO. 5027	69	86			
				MODEL 401-1C-2	71	88			

Figure 47. Conversion table for new type of tensiometer.

c. VALVE-STEM FISHING TOOL. (1) The valve-stem fishing tool consists of a cap fastened to a chain with a small T handle on the other end of the chain. The cap is threaded to fit a valve stem. (See fig. 49.)

(2) When replacing tires on rims the valve quite often slips inside. Sometimes it is impossible to reach the valve stem without taking the tire off the rim again. If a valve-stem fishing tool is fastened on the valve stem after the stem is inserted into the hole in the rim, the valve stem cannot get lost. The handle of the fishing tool is too large to go through the hole in the rim. After the tire is on, the valve can be pulled into place with the valve-stem fishing tool. Care should be exercised to prevent putting an excessive strain on the inner tube when pulling the valve stem into place.

d. VALVE REPAIR TOOL. For reconditioning air valves, the valve repair tool shown in figure 50 is used. The tap is used on the inside

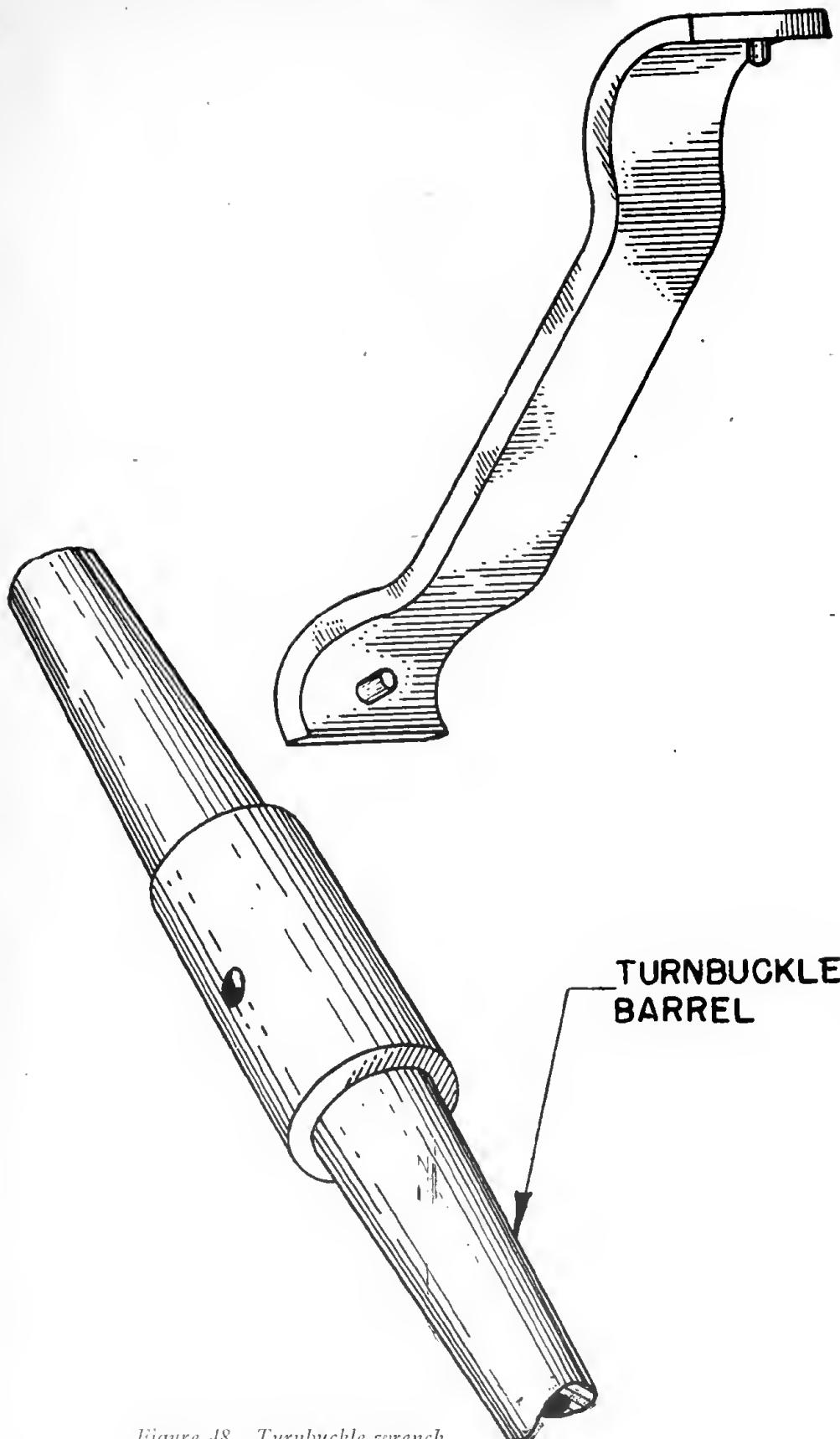


Figure 48. Turnbuckle wrench.

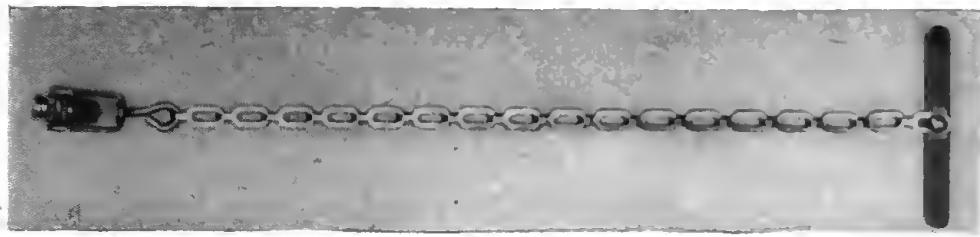


Figure 49. Valve-stem fishing tool.

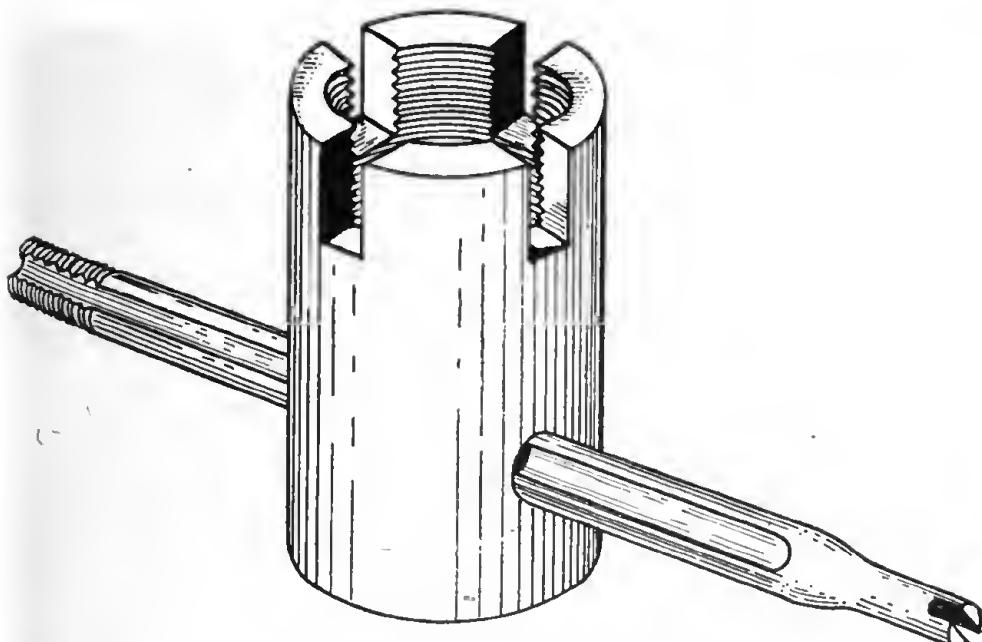


Figure 50. Valve repair tool.

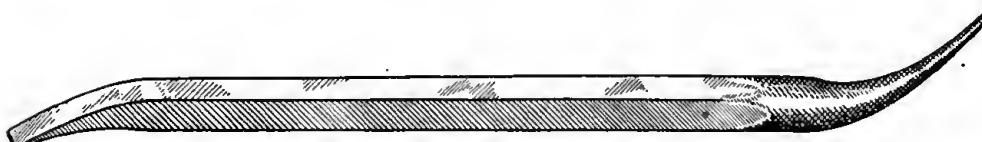
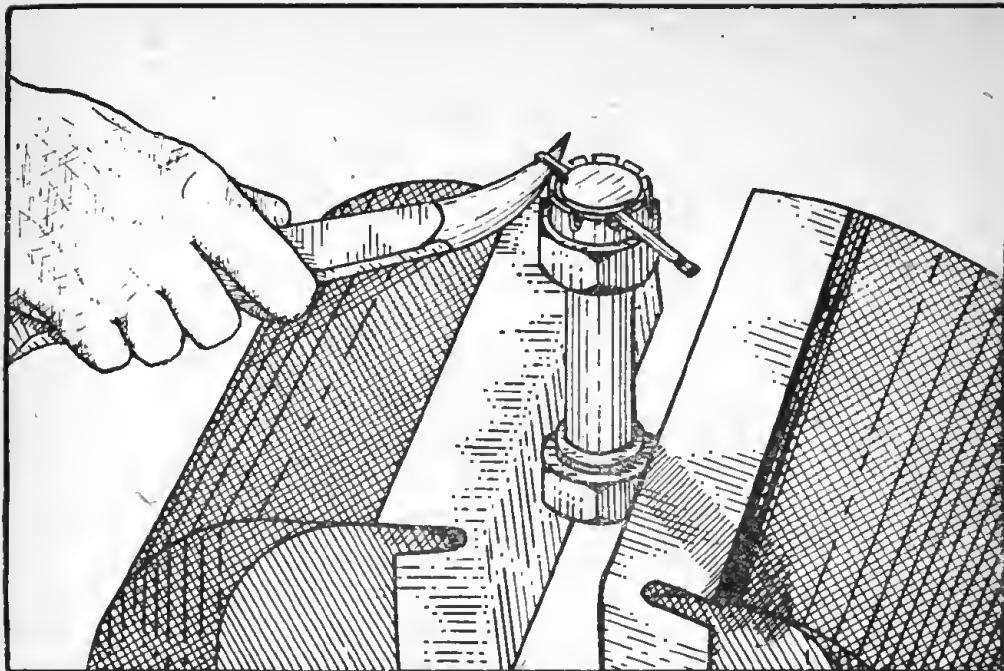


Figure 51. Cotter-pin extractor.

threads. The die is used on the outside threads. The end opposite the tap is used to remove the valve core.

e. COTTER-PIN EXTRACTOR. A cotter-pin extractor is simply a bar of steel with a curved taper on one end and a curved wedge on the other. (See fig. 51.) By inserting the point of the taper into the eye of the cotter pin with the outside of the curve bearing on some supporting material, the cotter pin can be removed by prying it out. Care should be taken to avoid damaging adjacent threads. The curved chisel end may be used to bend or straighten the ends of a cotter pin.

f. MECHANICAL FINGER. A mechanical finger (fig. 52) is a tube with long, flat springs running through it. At one end these springs are bent in toward the center. The other ends of the springs are fastened to a



Method of using cotter-pin extractor.

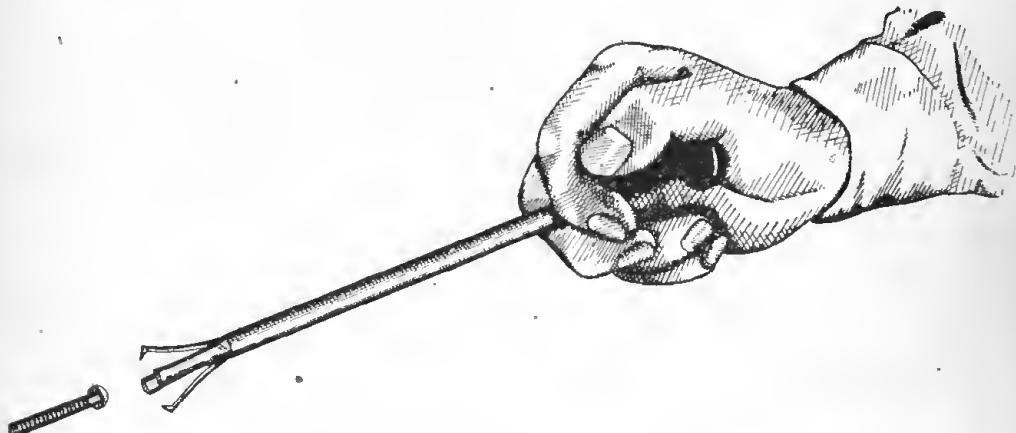


Figure 52. Using mechanical finger.

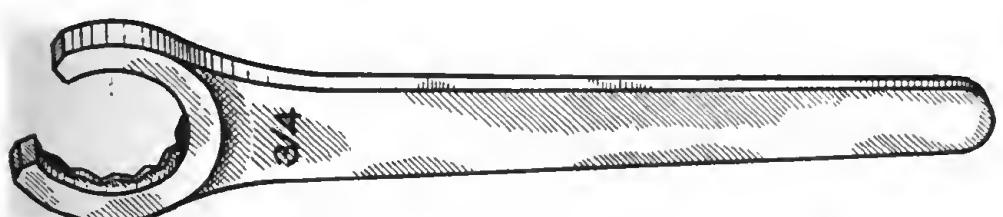
rod which protrudes from the end of the tube. The end of the tube has a collar on it to enable the mechanic to hold it between two fingers. The end of the rod has a small plate which is moved by the mechanic's thumb. There is a coil spring between the collar of the tube and the plate on the rod. This spring holds the plate away from the collar.

(1) The mechanical finger is used to retrieve small articles that have fallen into an out-of-reach place, or to hold a nut or bolt while starting to tighten it, or, in fact, to reach any place which the mechanic cannot reach with his fingers.

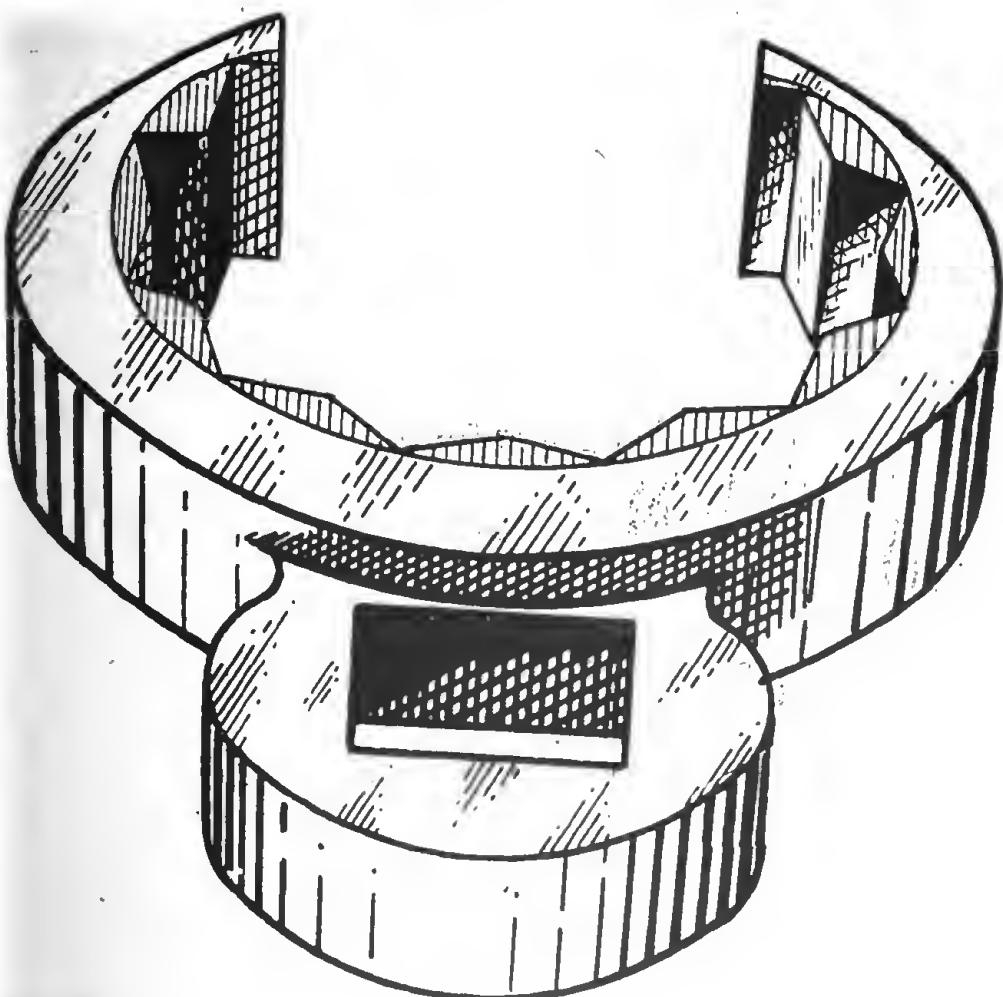
(2) When retrieving a nut with the mechanical finger, the mechanic presses on the plate, forcing the rod and the springs forward. As the



Figure 53. Brake-bleeding tool.



①



②

Figure 54. Tubing-nut wrenches.

ends of the springs emerge from the end of the tube they spread apart. The ends of the springs are then placed around the nut and the tube allowed to slide forward. This binds the springs around the nut and it can be withdrawn.

g. BRAKE-BLEEDING TOOL. (1) The brake-bleeding tool is a flat bar with a notch cut in one end. (See fig. 53.) It is used on some airplanes to bleed the brakes. It is placed between the brake-operating lever and the brake-control valve. By lifting on the end of the brake-bleeding tool, the brake-control valve is operated.

(2) This tool is used only on airplanes that have four brake-control valves and brakes which are bled internally. Pressing the brake pedal would operate two of the brake-control valves and this will not bleed the brakes.

h. TUBING-NUT WRENCH. (1) Two types of tubing-nut wrenches are shown in figure 54. If the type shown in figure 54 ① is not available one may be fabricated by the mechanic. An ordinary box-end wrench may have a section of the box cut out to allow it to be slipped over the tubing. This weakens the wrench, so that it cannot be used for any other purpose. The type shown in figure 54 ② is now standard. It has a $\frac{3}{8}$ -inch square drive.

(2) The tubing wrench is used to tighten and loosen tubing nuts. On brass or steel nuts an ordinary open-end wrench may be used in an emergency, but it is likely to round off the corners and distort the shape of an aluminum nut.

SECTION IV

MEASURING AND LAYOUT TOOLS

10. General

The work of a mechanic is no more accurate than the measurements he makes. It is important, therefore, that he learns to hold and read measuring instruments correctly. There are many different types of measuring instruments. Each type is best for a specific purpose. The most common unit of measure with which he will deal is the inch. It may be divided into fractions or decimals.

11. Tapes and Rules

a. GENERAL. The tape and rule are the measuring instruments most often used by the airplane mechanic. They are included in his tool kit and are used for all general measurements. They are graduated into fractions of an inch. These fractions may be expressed as $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, and $\frac{1}{64}$. Denominators greater than $\frac{1}{64}$ are not used because of the difficulty in reading them on the rule.

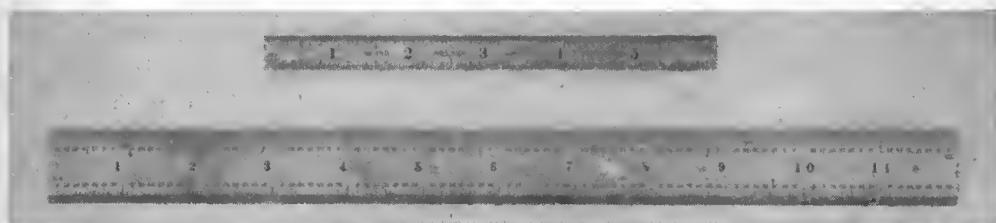


Figure 55. Measuring tape.

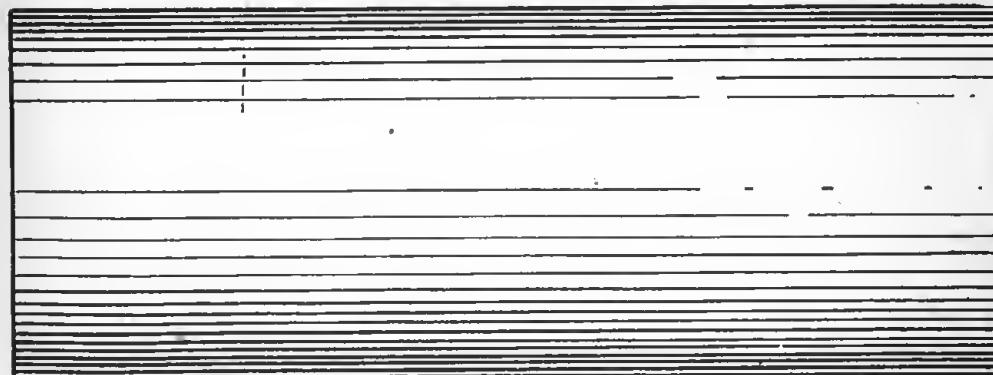
b. TAPES. (1) There are several kinds and lengths of tapes. The one used by an airplane mechanic (fig. 55) is 6 feet long and made of steel. It is coiled in a circular case. It may or may not have one end fastened permanently to the case. The tape may easily be drawn out of the case when needed and pushed back into the case when not needed. It is made of flexible steel and rolls up in the case as it is pushed in. It is graduated on one side only in $\frac{1}{16}$ - and $\frac{1}{32}$ -inch divisions. It has a small lip on the end. This lip prevents the tape from sliding completely

inside the case when not in use. It also enables the mechanic to line up the end of the tape easily with the end of a piece of stock.

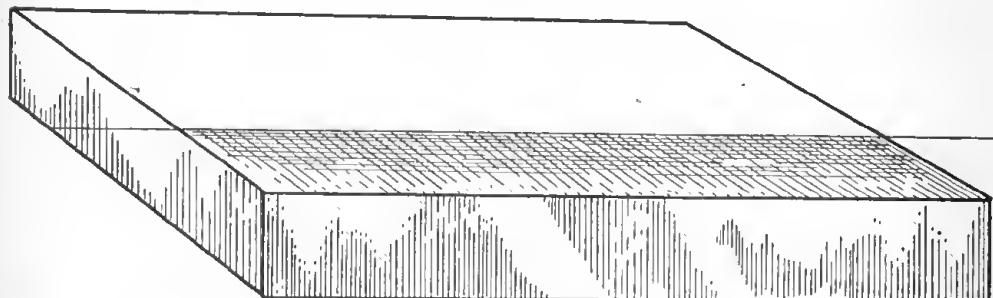
(2) The 6-foot flexible-steel tape is used to measure distances, length of stock, and for measurements that do not need to be too accurate. The tape cannot be read as accurately as the rule. The mechanic should learn to read a tape correctly. For instance, $\frac{9}{16}$ is not expressed as $4\frac{1}{2}/8$. It is $\frac{9}{16}$ and should be so read. The tape should be kept free from dirt and grit and lightly oiled. It should not be bent at a sharp angle. If it is, it will probably break.



(1)



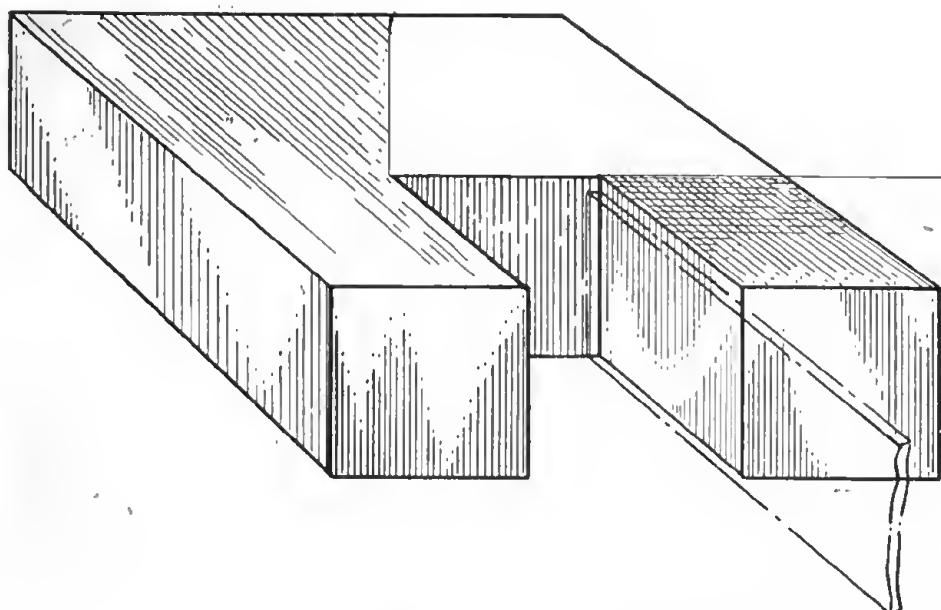
MEASURING ROUND STOCK



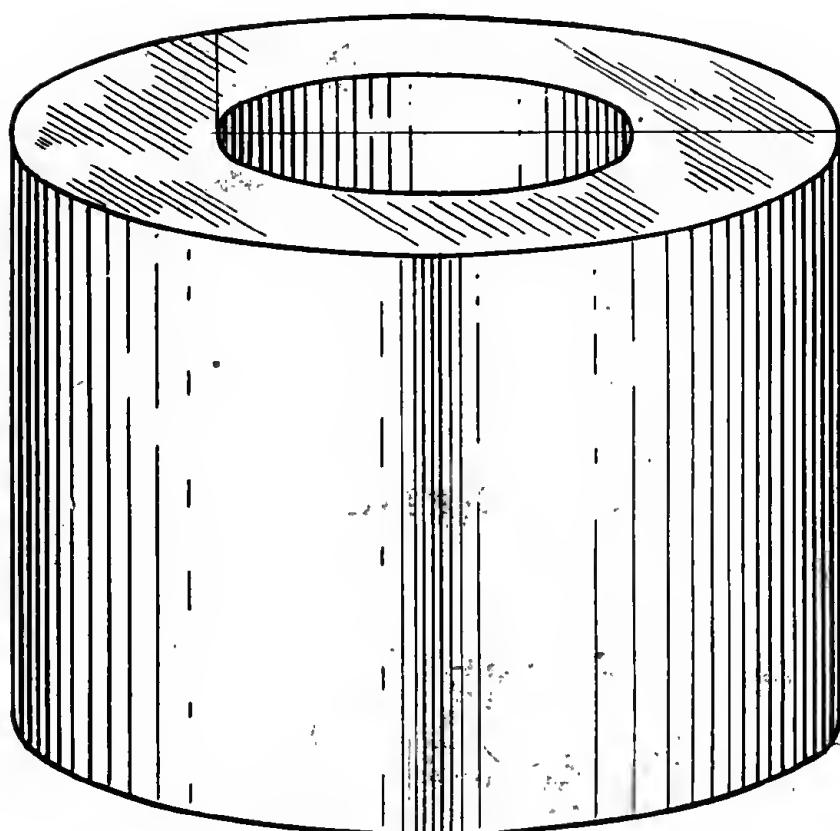
MEASURING A RECTANGULAR PIECE

(2)

Figure 56. Six- and 12-inch rules and their use.



MEASURING A SLOT



MEASURING THE DIAMETER OF A HOLE

©

Figure 56. Six- and 12-inch rules and their use.—Continued

c. RULES. (1) Rules, usually made of steel, are 4, 6, or 12 inches long and are either flexible or rigid. They are graduated in $\frac{1}{8}$ -, $\frac{1}{16}$ -, $\frac{1}{32}$ -, and $\frac{1}{64}$ -inch divisions.

(2) When the total length of a measurement is not too great the rule should be used. It is more accurate and easier to read than the tape. The rule is a measuring instrument and should be handled as such. It is not a screw driver, a pry, a scraper, nor a putty knife, and a good mechanic does not use it in place of one of these tools. Methods of taking measurements with the rule are shown in figure 56.

12. Gauges

a. GENERAL. Gauges are measuring instruments that are fixed. They have a series of openings of definite width or leaves of definite thickness. They are made of hard steel so that they will not lose their accuracy with use.

b. THICKNESS GAUGES. (1) Thickness gauges consist of thin leaves

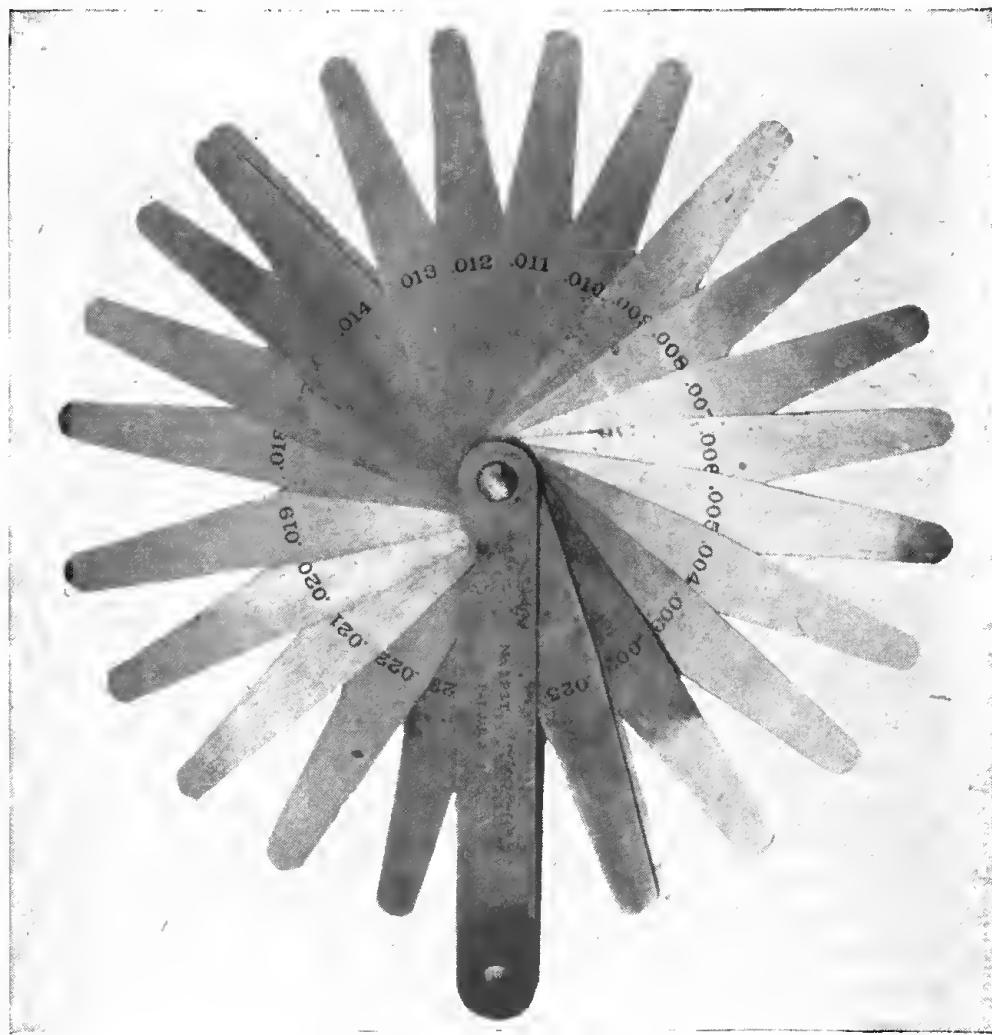


Figure 57. Thickness gauge.

of hard steel, each ground to a definite thickness. The leaves are usually in sets, with one end of each leaf fastened in a case. A set usually includes 26 leaves that range in size from 0.0015 inches to 0.025 inches. (See fig. 57.)

(2) Thickness gauges are used to measure clearances. One leaf at a time is tried until the thickest leaf which will enter the opening is found. The thickness of that leaf is then read and the clearance determined. The leaf should be wiped off before attempting to insert it into the opening. It should never be forced. Only light pressure should be applied. If it fails to enter, try the next smaller size. If the leaf is forced, it may spread the opening slightly, thus giving an inaccurate indication of size. There is also the danger of kinking the leaf and ruining it. If a leaf of the proper thickness is not available, two leaves may be wiped clean and used together.



Figure 58. Valve-clearance gauge.

c. VALVE-CLEARANCE GAUGE. A valve-clearance gauge is similar to a thickness gauge except that the end of the leaf is bent at about 45° to make it easier to insert between the rocker arm and the valve stem. (See fig. 58.) There are usually only five or six leaves. These are of the proper thickness for the valve clearance of most airplane engines. The use and care of a valve-clearance gauge is the same as that of a thickness gauge.

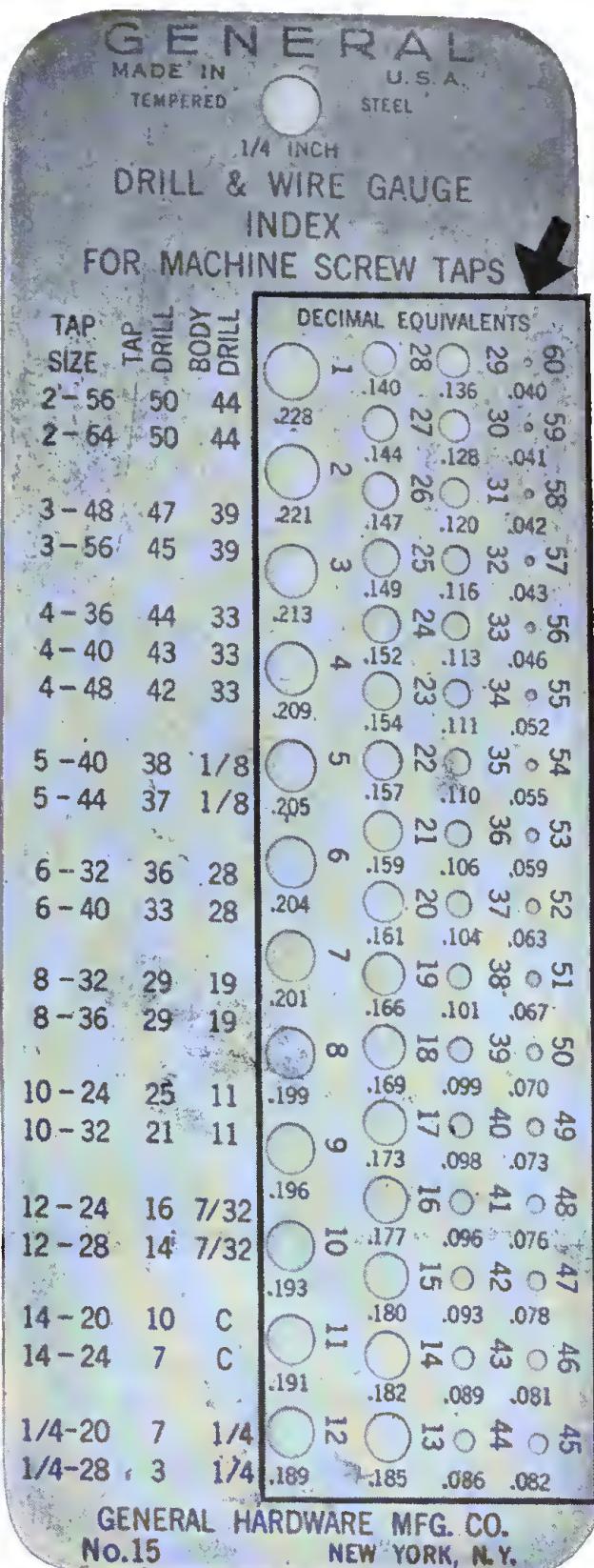


Figure 59. Twist-drill gauge.

d. TWIST-DRILL GAUGE. A twist-drill gauge is a circular or rectangular plate with a series of round holes in it. (See fig. 59.) These holes correspond in size to a series of drills. When it is necessary to drill a hole that a piece of wire or similar stock will fit into, the proper size of drill can be selected by trying the stock in the drill gauge. The gauge is also used to determine the size of a drill when the size mark on the shaft of the drill cannot be read.

e. SHEET-METAL AND WIRE GAUGES. Sheet-metal and wire gauges are similar to twist-drill gauges except that they have slots instead of holes around the edges. The thickness of a piece of sheet metal or the diameter of a wire can be determined by trying it in the slots of the gauge. (See fig. 60.) Galvanized sheet metal should not be gauged on the original edge; the zinc is sometimes thicker there. The metal should be cut and the cut edge gauged for thickness. Sheet-metal and wire gauges are not always identical. They are just the same in shape, but the widths of the slots are sometimes different. In fact, there are several standard

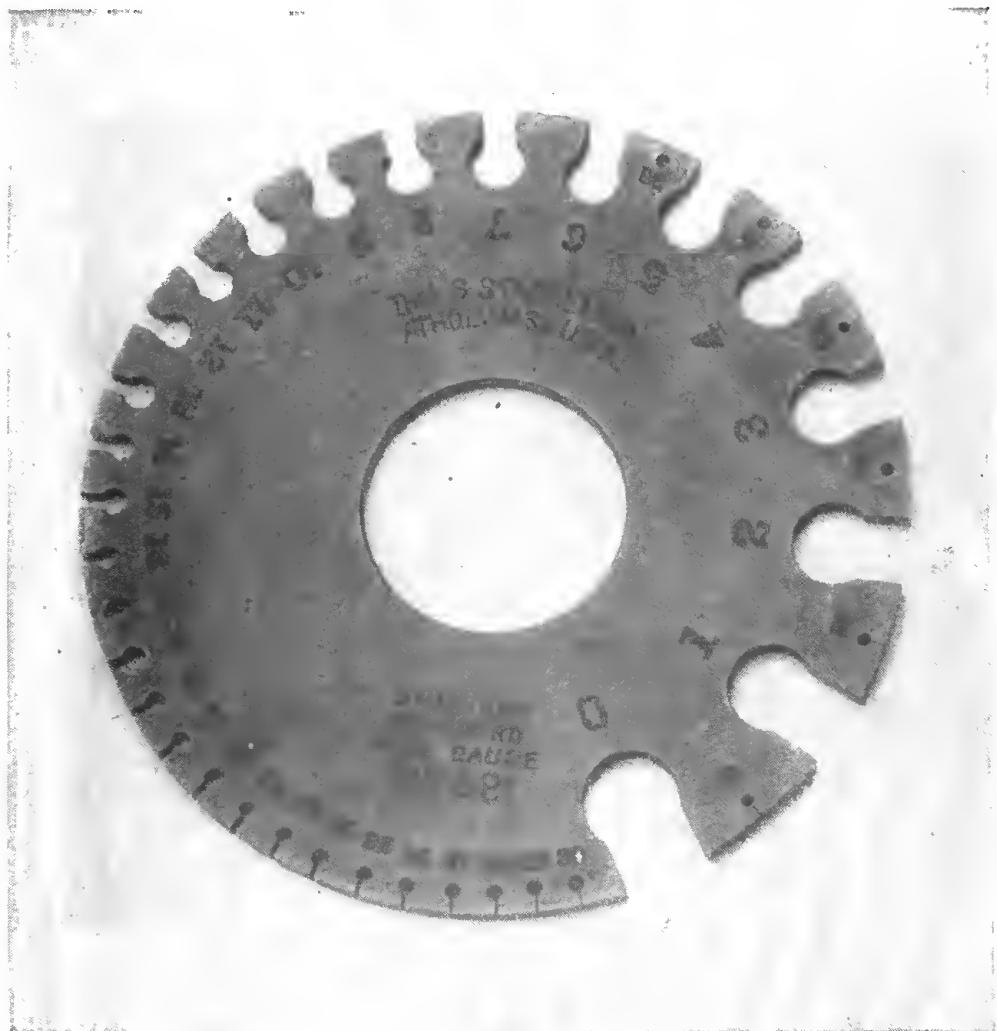
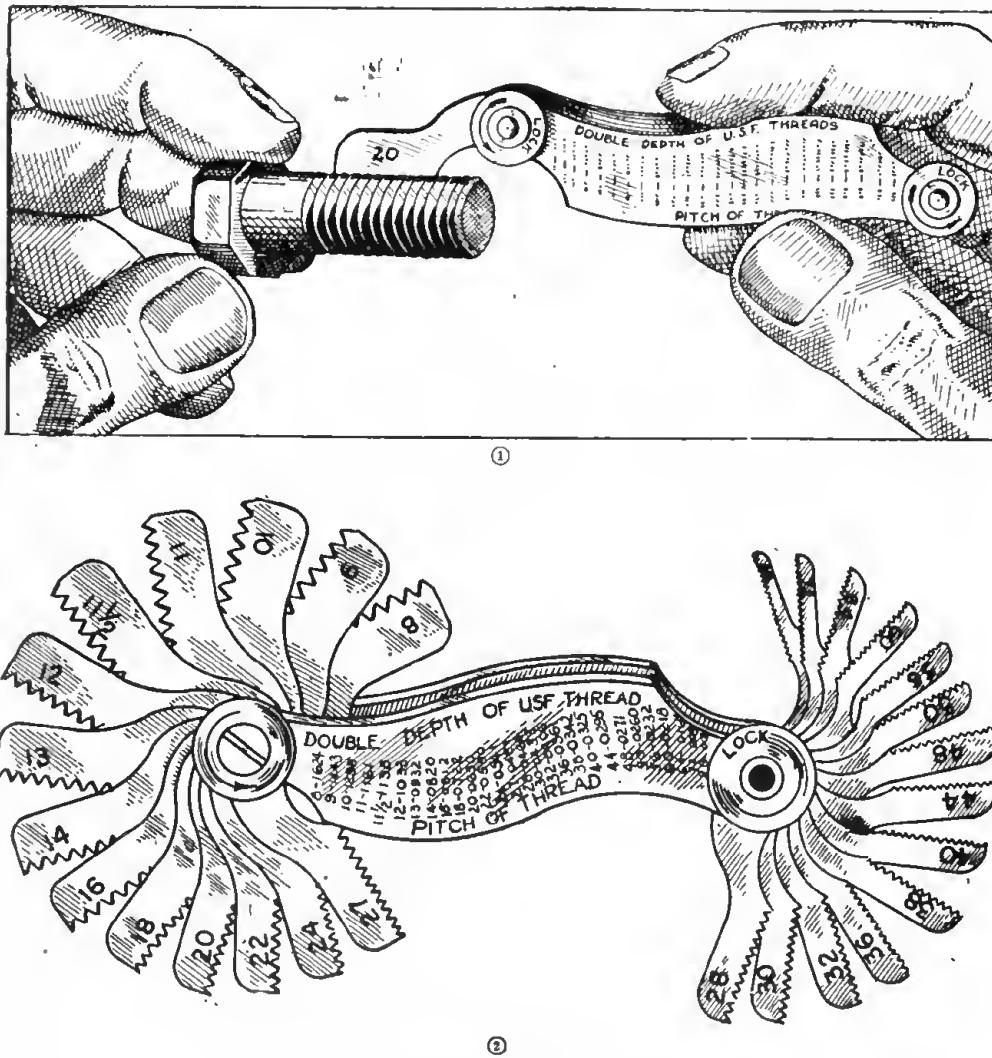


Figure 60. Wire gauge.

gauges such as American Standard, English Standard, and U. S. Standard. The mechanic should make certain he has the proper one for the material being gauged. For most sheet metal and wire on an airplane, the American Standard gauge is used.

f. THREAD GAUGE. The thread gauge (screw-pitch gauge) is similar to the thickness gauge. However, the leaves are all of the same thickness. The edges of the leaves have teeth on them. (See fig. 61.) The number



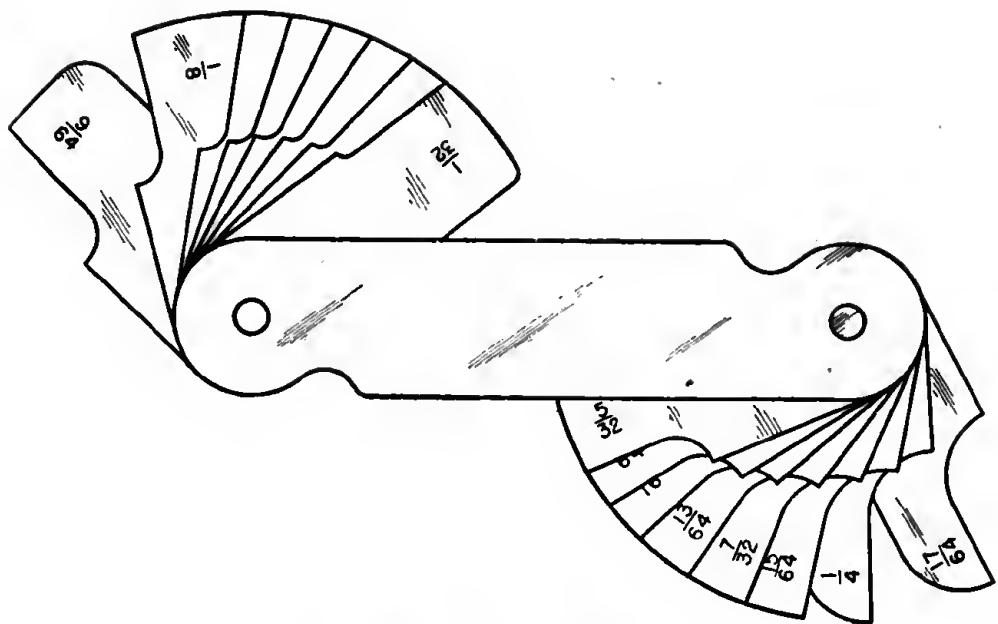


Figure 62. Radius gauge.



Figure 63. Drill-grinding gauge in use.

h. DRILL-GRINDING GAUGE. (1) The drill-grinding gauge is shaped like the letter "T." The ends of the cross-bar of the "T" are cut off at an angle of 59°. This is the correct angle for the cutting lips of a drill. The edge of the gauge is marked off in $\frac{1}{64}$ -inch divisions to enable the mechanic to measure the length of the lips as well as the angle. For special work, gauges may be cut at angles of 40 to 70°, but 59° is used for all general work.

(2) To check the angle of the cutting lip of a drill after grinding, the gauge is held against the drill as shown in figure 63. The drill is then turned around and the other lip checked. If the lips do not have the correct angle and the same length, the drill must be reground.

i. Go, no-go GAUGES. Go, no-go gauges are used mostly in production work. One end is the go end and it should fit the machined part. The other is the no-go end and it should not fit. If the go end fits and the no-go does not, the part is within the specified tolerance. Two types of go, no-go gauges are shown in figure 64.

13. Calipers

a. GENERAL. Calipers are classified as spring or sliding, and as inside or outside. They are more accurate than a ruler, and when used properly with a micrometer, they can be used to take measurements to within 0.001 inch.

b. SLIDE POCKET CALIPERS. (1) These calipers (also called sliding calipers) have a fixed jaw fastened to the end of a bar and a movable jaw fastened to a frame which slides on this bar. (See fig. 65.) The bar has a scale on it and the frame has two index marks labeled "In" and "Out." One side of the jaws is made to take outside measurements. The other side of the jaws is made to take inside measurements.

(2) To measure the outside diameter of a round bar or the thickness of a flat bar, the jaws of the calipers are opened and placed over the stock. The movable jaw is then slid forward until the jaws just touch the stock. The calipers may then be removed and the dimension opposite the "Out" index mark can be read. To take an inside measurement, the jaws are placed inside and spread apart until they just touch the stock. The dimension may then be read as before, using the "In" index mark. Sliding calipers should be kept clean and oiled. They should never be jammed tightly on the stock. If they are, the jaws are likely to be sprung and the calipers will be ruined.

c. SPRING CALIPERS. Spring calipers are shown in figure 66. They have no scale and are used only to transfer dimensions. They are quite often used on lathe work. By adjusting them to the proper position, they may be used to determine when sufficient stock has been cut away. (See fig. 67.) Spring calipers should not be used when the stock is moving, nor should they be forced on the stock. They will probably not be damaged, but they will spring slightly and give an inaccurate measurement.

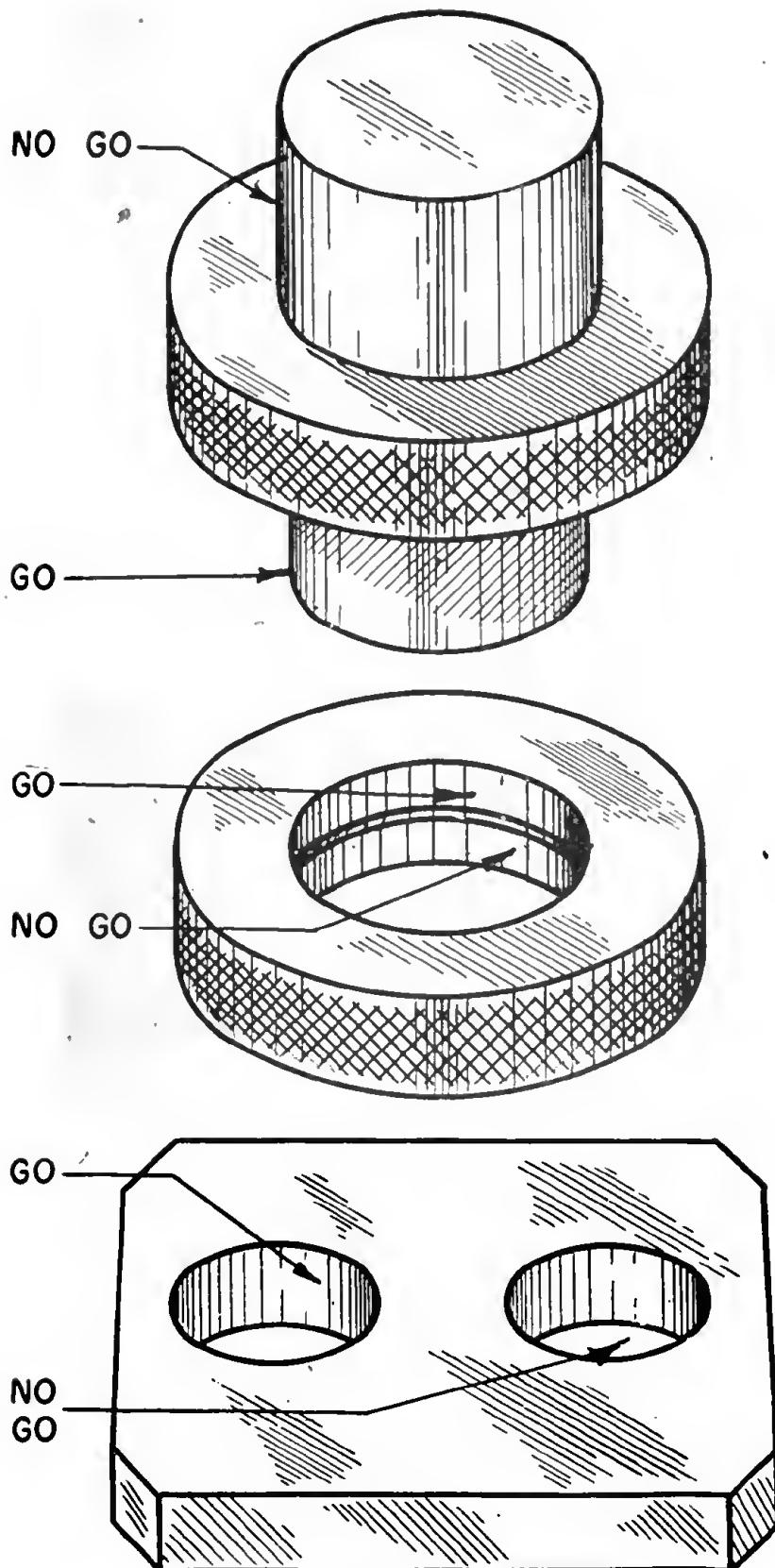


Figure 64. Go, no-go gauges.

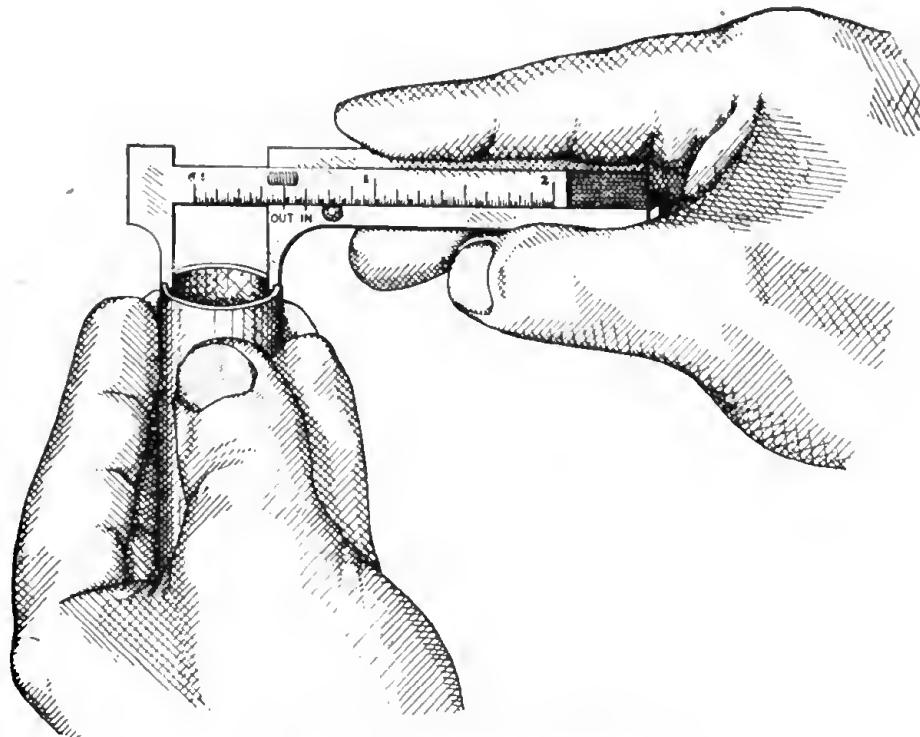


Figure 65. Using sliding calipers.

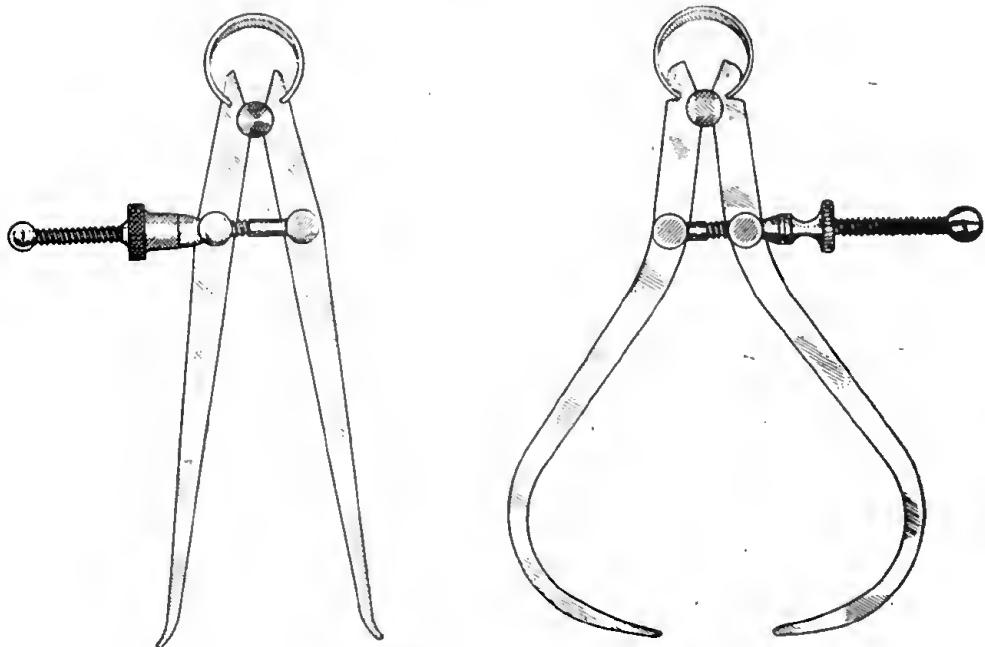


Figure 66. Spring calipers.

d. HERMAPHRODITE CALIPERS. (1) Hermaphrodite calipers should have a point on one arm and a bearing surface on the other. (See fig. 68.) They are used to scribe an arc or a line parallel to the edge of a piece of stock.

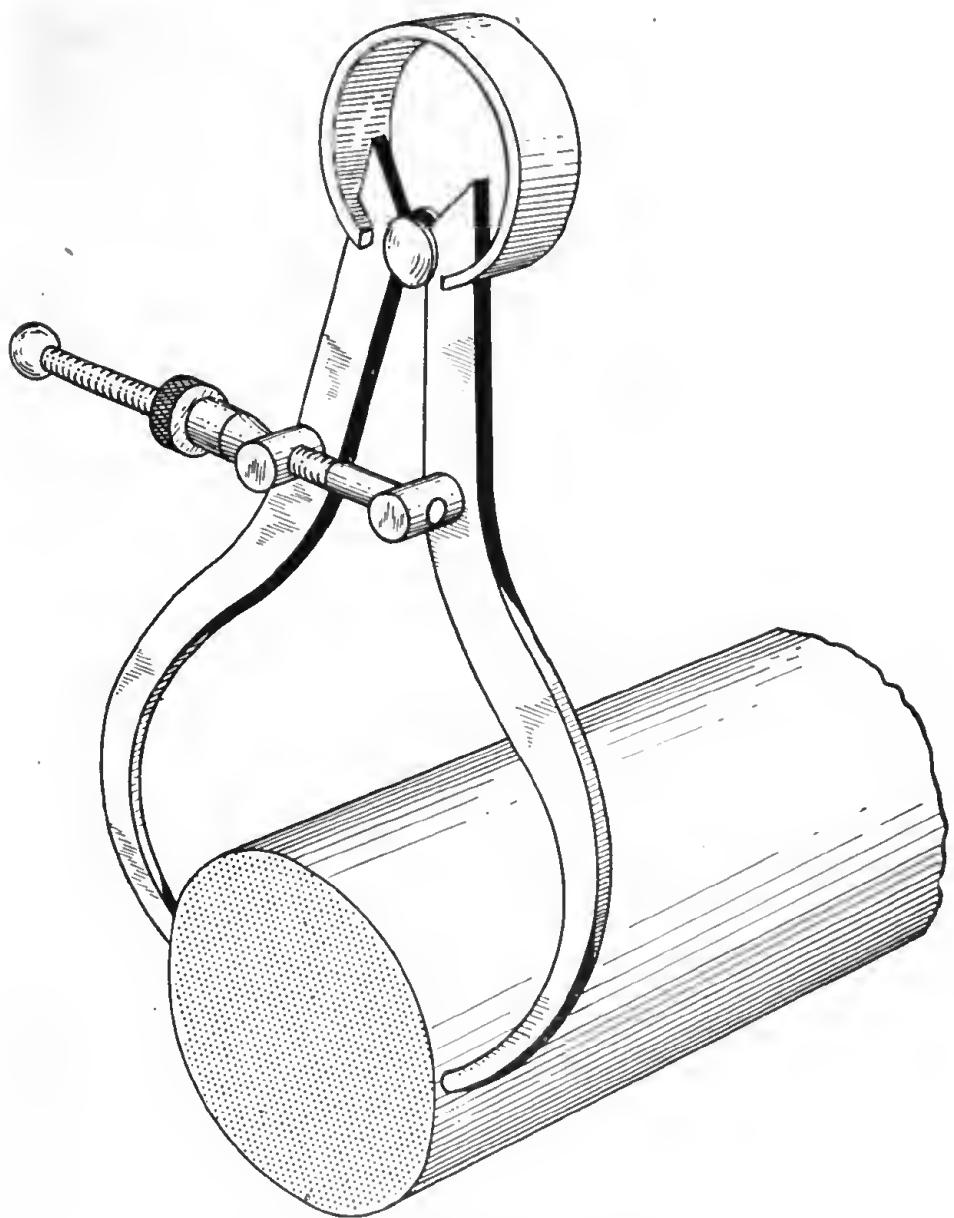


Figure 67. Spring calipers in use.

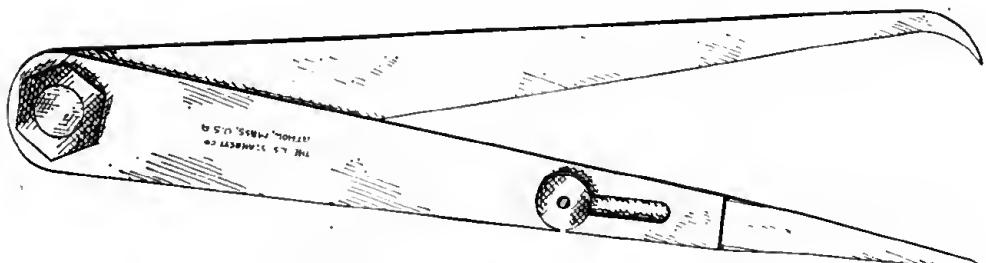


Figure 68. Hermaphrodite calipers.

14. Micrometers

a. GENERAL. The micrometer is the most accurate of the adjustable measuring instruments. The internal parts of a micrometer are not cut on a lathe, but are ground to size on a machine grinder. It is normally used to measure to within 0.001 inch and if equipped with a vernier scale, it will measure to within 0.0001 inch.

b. PRINCIPLES OF OPERATION. A drawing of a micrometer is shown in figure 69. The screw has 40 threads per inch. Therefore, when the

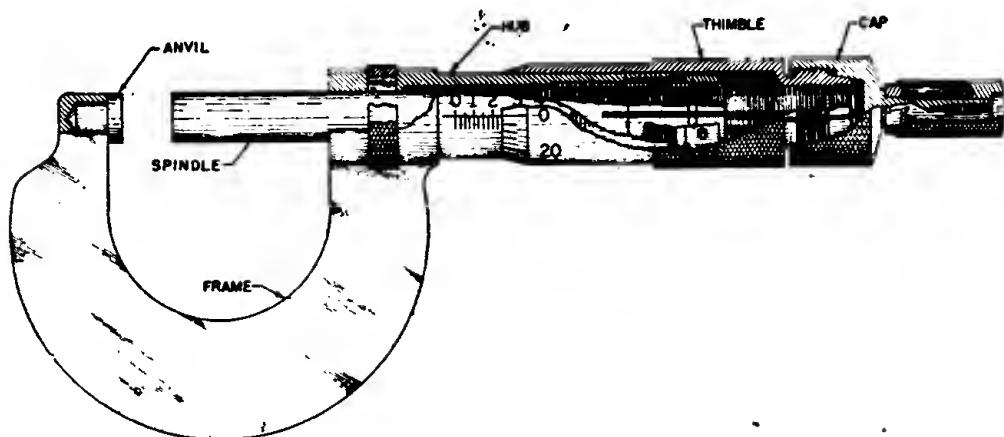


Figure 69. Micrometer.

thimble is turned one complete revolution, the end of the spindle is moved $\frac{1}{40}$ or 0.025 inch. The barrel of the micrometer is marked off in 40 equal spaces so that the number of revolutions made by the thimble may be known. The outside of the thimble is marked off in 25 equal spaces. As the thimble is turned the distance between two of the marks, the spindle is moved 0.001 inch to or from the anvil. By adjusting the micrometer to a piece of stock so that the anvil and spindle just touch the stock and then reading the micrometer, the size of the stock may be determined.

c. TYPES. Different types of micrometers are used for different kinds of work. The only difference between them is in the housing or frame. (See fig. 70.) The principle of operation of all the types is the same.

(1) *The outside micrometer* is used more often than any other type. With it the mechanic can measure the outside diameter of shafts, the thickness of stock, and make other similar measurements. It is also used to set inside calipers to a given dimension.

(2) *An inside micrometer* is used to measure the inside diameters of cylinders, the width of recesses, and for other similar work.

(3) *A thread micrometer* is used to measure the pitch diameters of screws and bolts.

(4) *A depth micrometer* is used to measure the depth of a recess or hole.

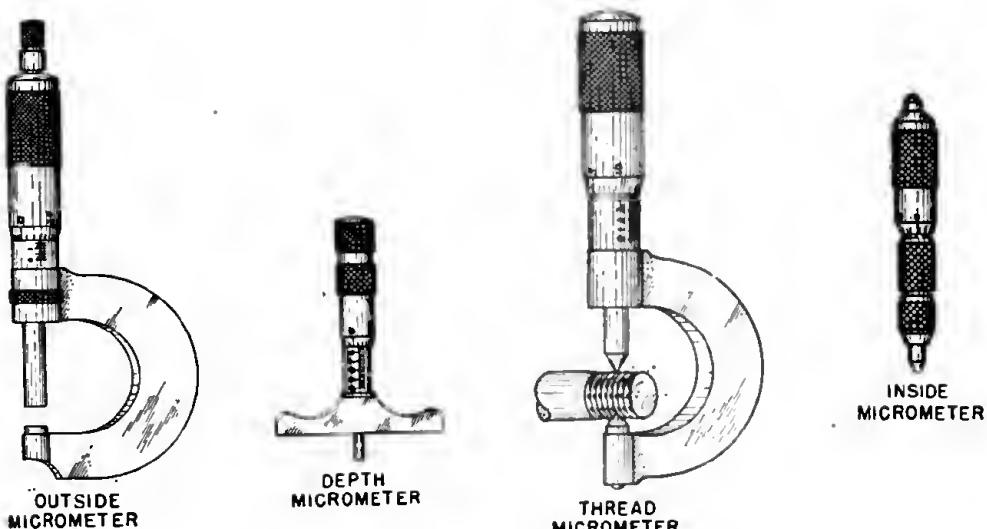


Figure 70. Four types of micrometers.

d. SIZE. The range of a micrometer is usually 1 inch. The size of a micrometer is given as the largest dimension it will measure. Therefore, a micrometer which will measure from 0 up to 1 inch is called a 1-inch micrometer. A 2-inch micrometer will measure from 1 to 2 inches. A 20-inch micrometer will measure from 19 to 20 inches. An outside micrometer has the mechanism fastened to the frame and therefore is of a definite size. The inside micrometer has a series of bars which will fit into the mechanism. By choosing a bar of the proper length and inserting it into the mechanism, a micrometer of any size can be made. (See fig. 71.) A depth micrometer also has extension bars.

e. READING MICROMETER. (1) Reading a micrometer correctly is difficult. The student mechanic should practice using one until he becomes

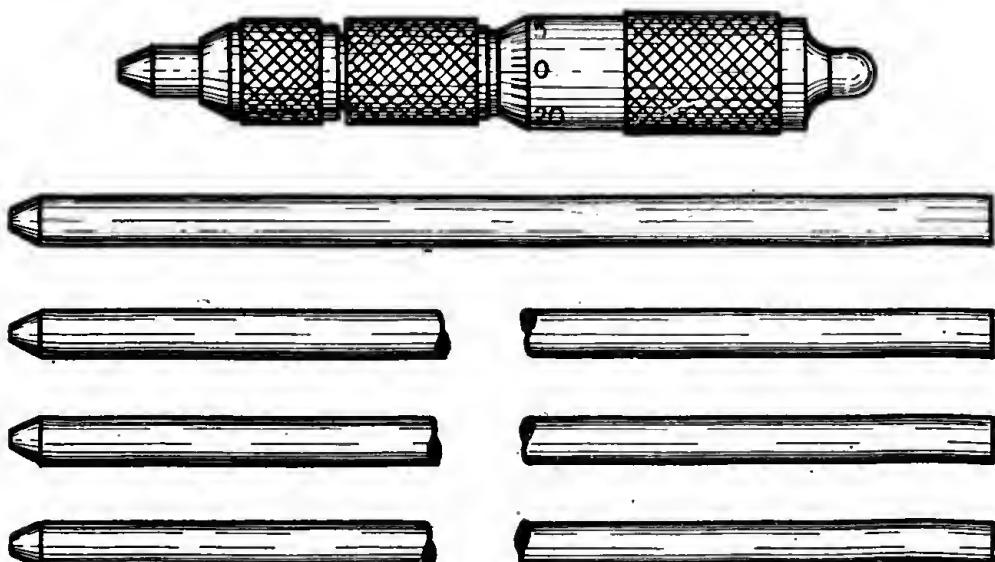


Figure 71. Inside micrometer and extra extension bars.

proficient. A micrometer is of no value if the mechanic does not know how to use it.

(2) The barrel of the micrometer is marked off into 10 equal spaces. These marks are numbered from 0 to 10. Each space equals $\frac{1}{10}$ inch and

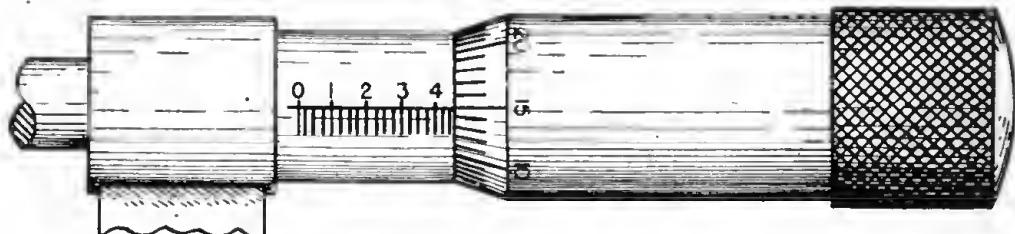
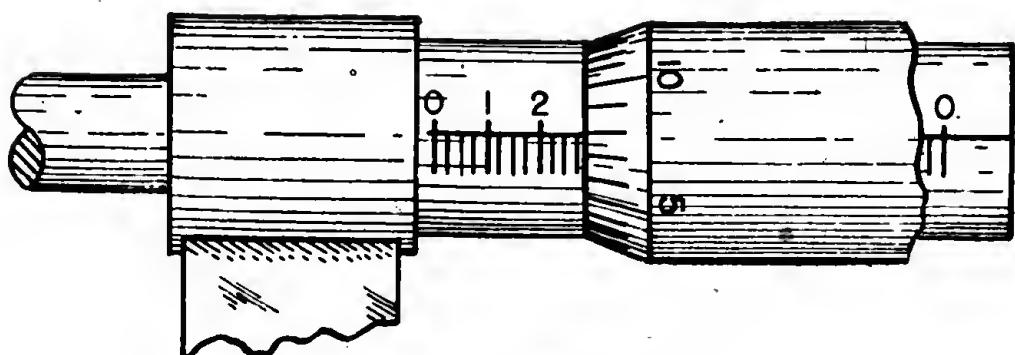
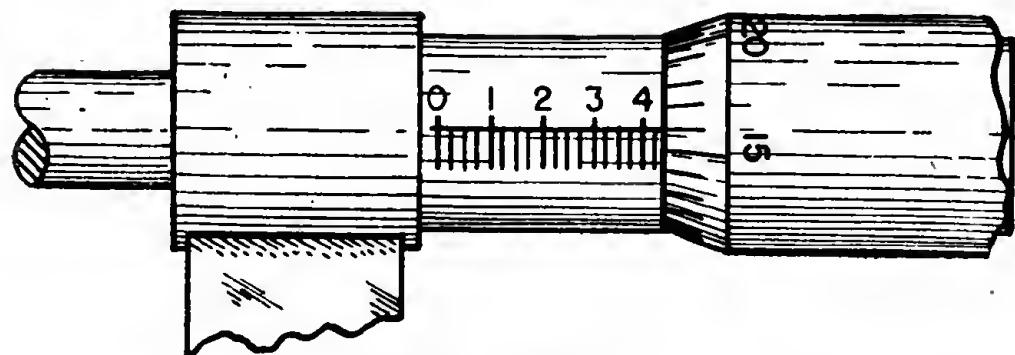


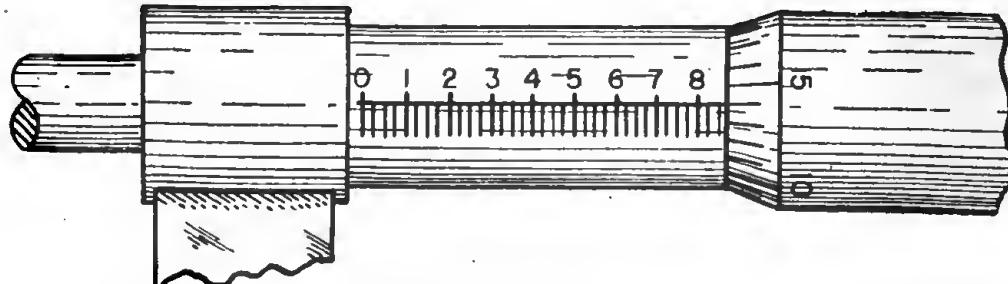
Figure 72. Micrometer reading.



① Correct reading 0.283.



② Correct reading 0.441.



③ Correct reading 0.864.

Figure 73. Readings on a micrometer.

is divided into four smaller spaces. Each of these smaller spaces, therefore, equals $\frac{1}{40}$ inch or 0.025 inch. One complete revolution of the thimble will move the spindle the distance of one of the smaller spaces. The circumference of the thimble is marked off in 25 equal spaces. Since a complete revolution of the thimble moves the spindle 0.025 inch, turning the thimble the distance of one of the 25 small spaces on it will move the spindle 0.001 inch. Therefore, to read the setting of a micrometer, the number of $\frac{1}{10}$ inches is read first, then the $\frac{1}{40}$ or 0.025 inches, and then the $\frac{1}{1000}$ inches. They are all added together and the setting of the micrometer is determined. For example, in figure 72 the micrometer shows $\frac{4}{10}$, $\frac{2}{40}$, and $\frac{15}{1,000}$ inches. Four tenths plus $\frac{2}{40}$ plus $\frac{15}{1,000}$ inches is written $0.4 + (2 \times 0.025) + 0.015 = 0.4 + 0.050 + 0.015 = 0.465$. The correct reading then is 0.465 inch. Other examples of micrometer settings with the correct reading are shown in figure 73.

(3) For very accurate work it is sometimes necessary to read the micrometer to within $\frac{1}{10,000}$ inch. In order to be able to do this, the micrometer must have a vernier scale on it. The vernier scale is located on the barrel. It is a series of 11 lines marking off 10 spaces parallel to the center line of the barrel. (See fig. 74.) The space between two of

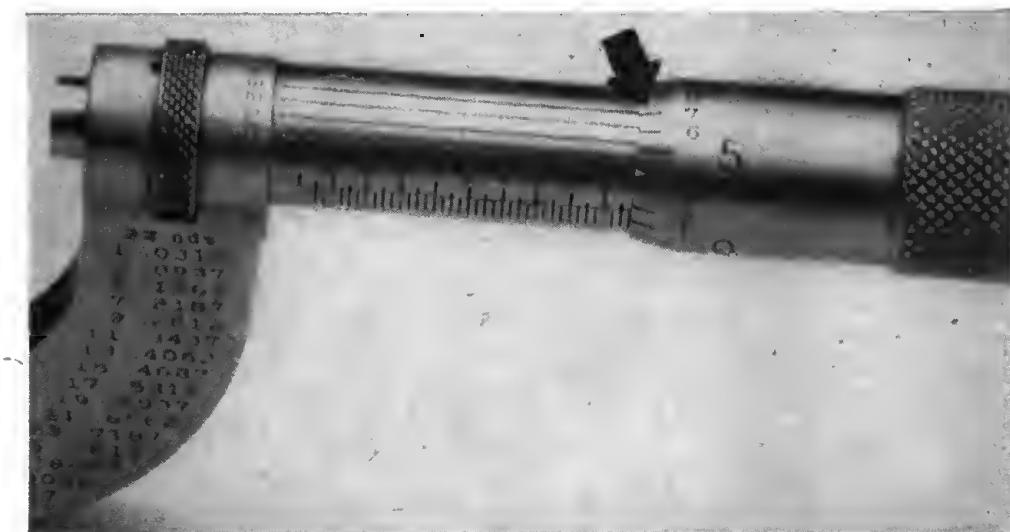


Figure 74. Vernier scale on a micrometer.

these lines is equal to $\frac{1}{10}$ of the space between two of the marks on the thimble. Therefore, the difference between the width of the spaces on the barrel and of the spaces on the thimble is $\frac{1}{10}$ of $\frac{1}{1,000}$ or $\frac{1}{10,000}$ of an inch. To read a micrometer with a vernier scale, the number of thousandths is found in the conventional manner. The vernier scale is then observed to see which of its marks is in line with a mark on the thimble. If it is line 0, the reading is in even thousandths. If it is line 1, there is $\frac{1}{10,000}$ in addition to the other reading. It it is

line 2, there are $\frac{2}{10,000}$, etc. For example, in figure 75 the micrometer reads 0.573 inch, and on the vernier scale line 3 is lined up with a mark

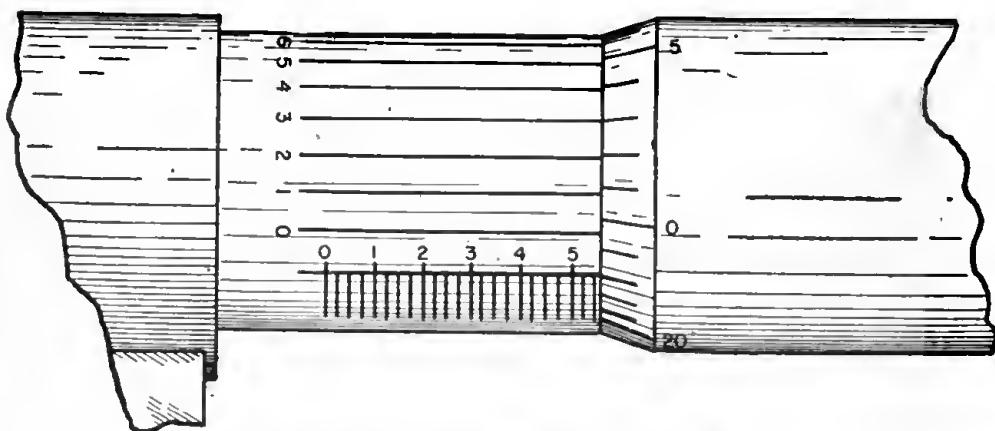
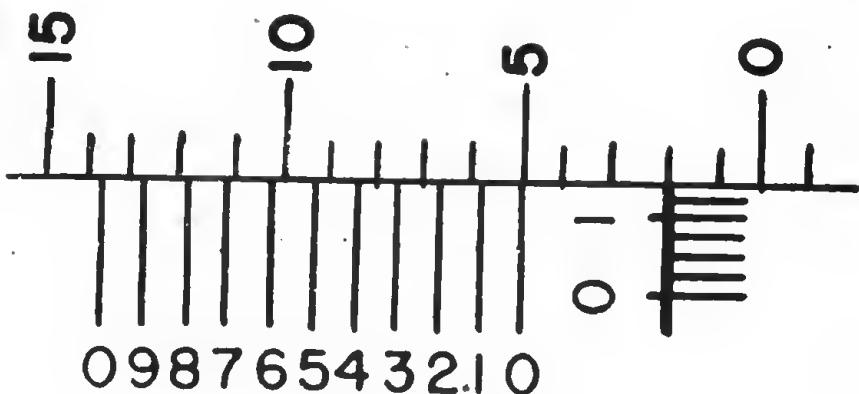
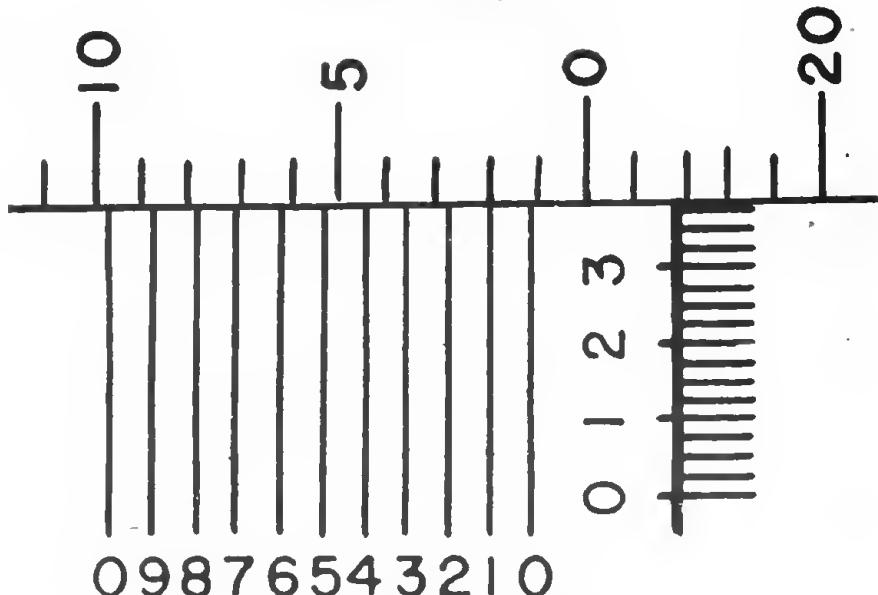


Figure 75. Vernier micrometer reading.

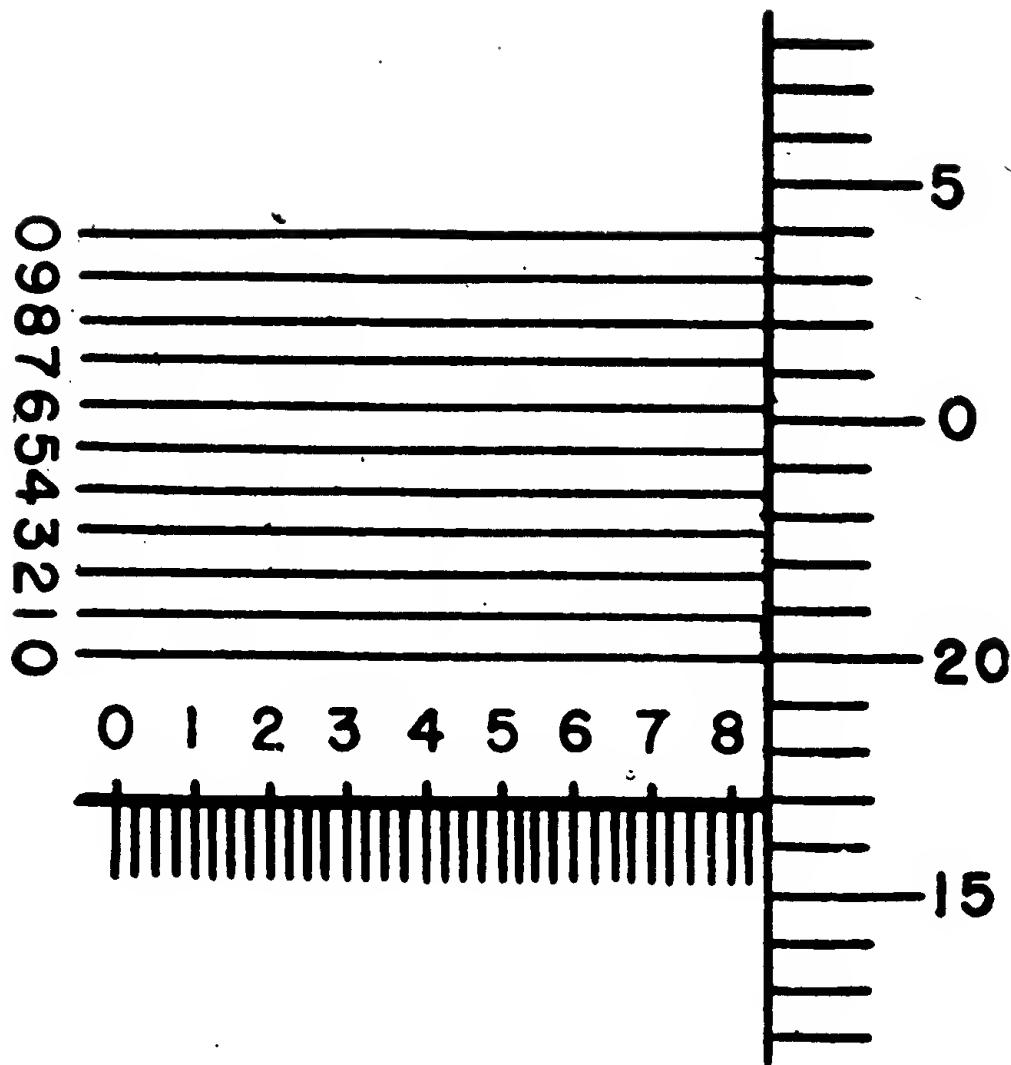


① Correct reading 0.1270.



② Correct reading 0.3981.

Figure 76. Readings on a vernier micrometer.



③ Correct reading 0.8414.

Figure 76. Readings on a vernier micrometer.—Continued

on the thimble. Therefore, the correct reading for the micrometer is 0.5733 inch. Other examples of vernier micrometer settings with the correct readings are shown in figure 76.

f. USE AND CARE. (1) The first step in using a micrometer is holding it correctly. It should be held as shown in figure 77. This leaves one hand free to hold the stock that is being measured. On large work the micrometer is held in both hands. The thumb and first finger are used to turn the thimble until the anvil and spindle just touch the stock. Only a very slight tension should be applied, and it should be the same every time the micrometer is used. It is rather easy to spring a micrometer $\frac{1}{1,000}$ inch and thereby get an inaccurate reading. Many micrometers have a ratchet on the end of the thimble which will slip when the tension becomes great enough. This is an aid to the beginner since it prevents overtightening. The spindle of the micrometer should always



Figure 77. Correct way to hold a small micrometer.

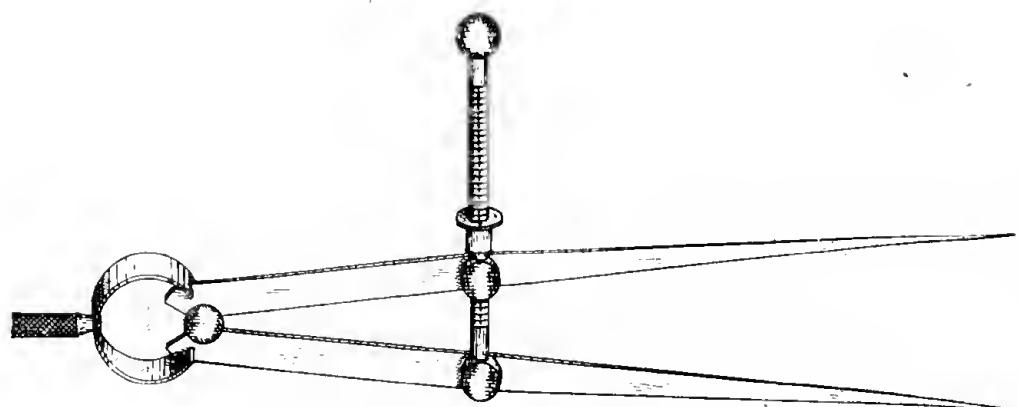


Figure 78. Dividers.



Figure 79. Scriber.

be perpendicular to the material being measured. If it is not, the micrometer reading will be slightly greater than the actual size of the stock.

(2) The micrometer is the most delicate of the measuring instruments normally used by the airplane mechanic. Rough handling can easily throw it out of adjustment. It should always be laid down gently. It should never be dropped. It should be kept lightly oiled, but with clean oil only. Dirty engine oil or other oil that has been used should not be allowed to get on the micrometer. Fine particles of dirt are likely to get inside the micrometer and cause it to turn hard and wear rapidly. The micrometer should never be screwed down tight on the stock being measured; tightening too much just once can spring the mechanism so that it will not be accurate.

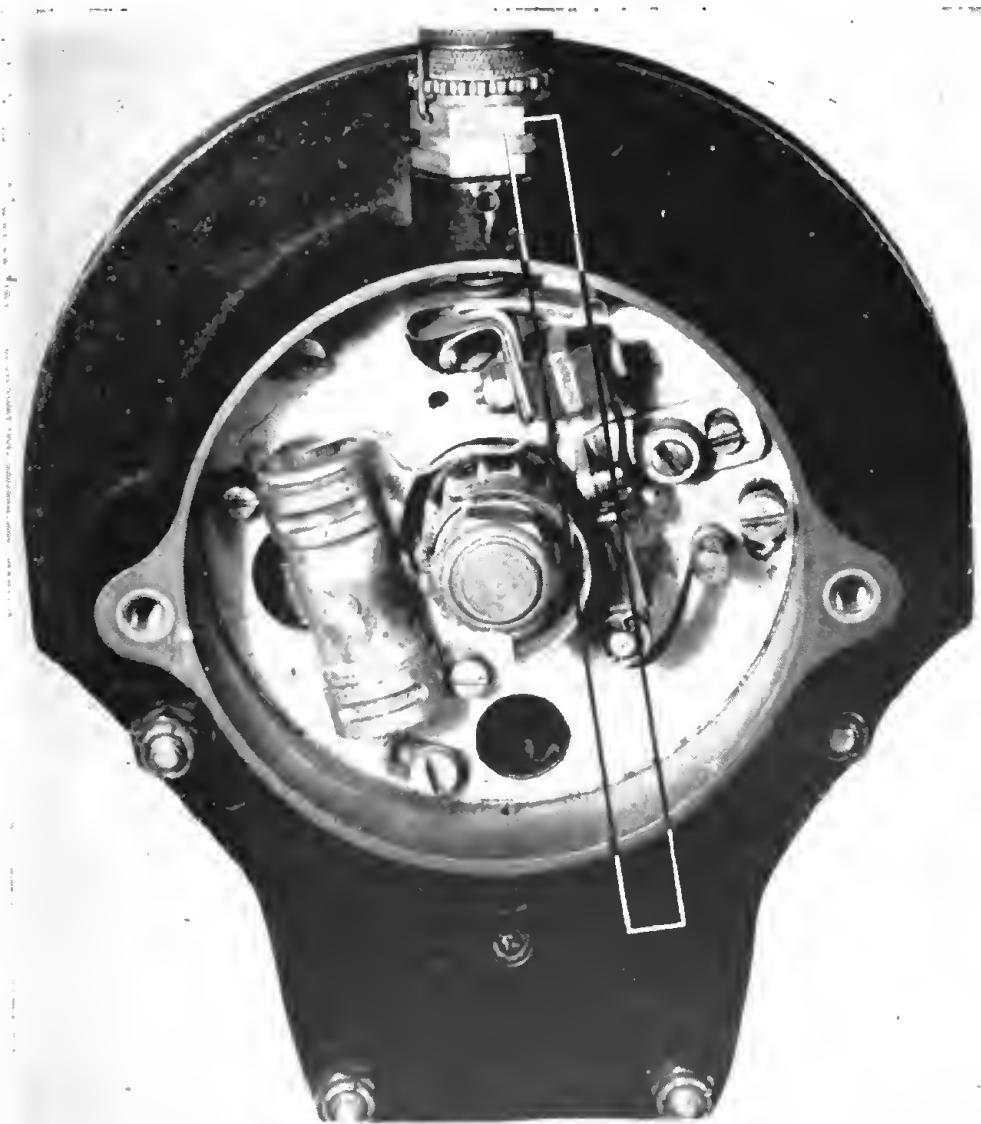


Figure 80. Use of a timing straight edge.

15. Dividers

Dividers are tapered-steel picks hinged together on the blunt end. (See fig. 78.) They are used to scribe arcs and circles and transfer measurements when laying out work. The points of the dividers are the parts which actually do the work. They should be kept sharp and care should be taken to prevent bending them.

16. Scribes

A scribe is a sharp, hard-steel pick. (See fig. 79.) It is used when laying out work on metal as a pencil is used when drawing on paper. A scribe is not used on Alclad aluminum or aluminum alloy where the scribed line will not later be cut off.

17. Special Measuring Tools

a. **TIMING STRAIGHT EDGE.** A timing straight edge is simply a thin piece of steel about 6 inches long, the edges of which are straight. It is used when timing a magneto. The rotor of the magneto is turned until the breaker points just separate. The straight edge is then used to check the alignment of two edges on the rotor with two marks on the housing. (See fig. 80.)

b. **TIMING SEGMENT.** The timing segment is usually made of brass. It is a thin plate and is curved to fit the nose section of the engine. It has a $\frac{3}{8}$ -inch hole drilled in each end and has some reference marks



Figure 81. Timing segment in place on an engine.

stamped on it. (See fig. 81.) The segment is used to time the ignition and valves of a radial engine. It is bolted to the engine near the propeller shaft where two bolt holes are provided. With the proper piston at top dead-center, a pointer is lined with the center reference mark on the segment. The pointer is fastened so that it must rotate with the shaft. When the shaft is rotated, the amount of rotation can be read on the timing segment.

SECTION V

FABRICATING TOOLS

18. General

In the United States in peace time the AAF airplane mechanic does very little fabricating work himself. Depots furnish the replacement parts and the mechanic installs them. Necessary work on an airplane other than the replacement of parts is done by subdepot personnel. In the actual combat zone the situation is different. Minor damage to an airplane caused by antiaircraft and machine-gun fire is repaired by the airplane mechanic. It is important therefore, that he understand the proper use of the tools needed for this type of work.

19. Holding Devices

a. GENERAL. Material that is being worked to a definite shape and size must be held firmly while the work is being performed. Vises and clamps are used for this purpose. There are many different types of holding devices, but only the bench vise, woodworking vise, handscrews, and carriage clamp will be covered in this manual.

b. BENCH VISE. (1) A bench vise is shown in figure 82. The upper part may be rotated on the base by loosening the lock screw on the side. The replaceable jaws are scored on the face to provide a better gripping surface. The screw provides a means of tightening the jaws. The vise is made of malleable and hard steel.

(2) When material is held in the vise, it should be held tightly enough that it cannot slip nor chatter. Thin material should be clamped so that the part being worked is as close to the edge of the vise as possible. This will help prevent chattering. When clamping finished surfaces, a piece of scrap copper, brass, or aluminum should be inserted between the work and each jaw of the vise. There is a greater danger of the work slipping when clamped in this manner, but the scored jaws would otherwise ruin the finished surface. In fact, most mechanics shape two scraps of brass, copper, or aluminum so that they will fit over the jaws of the vise and then save them to be used whenever holding finished surfaces. The amount of force used to tighten a vise depends upon what is being held. For heavy, rough stock, the vise may be tightened as much as the mechanic can turn it. It should be tightened by hand power alone, however. A hammer or mallet should never be used. Lighter material is more difficult to hold since there is danger of bending it. Tubular stock is

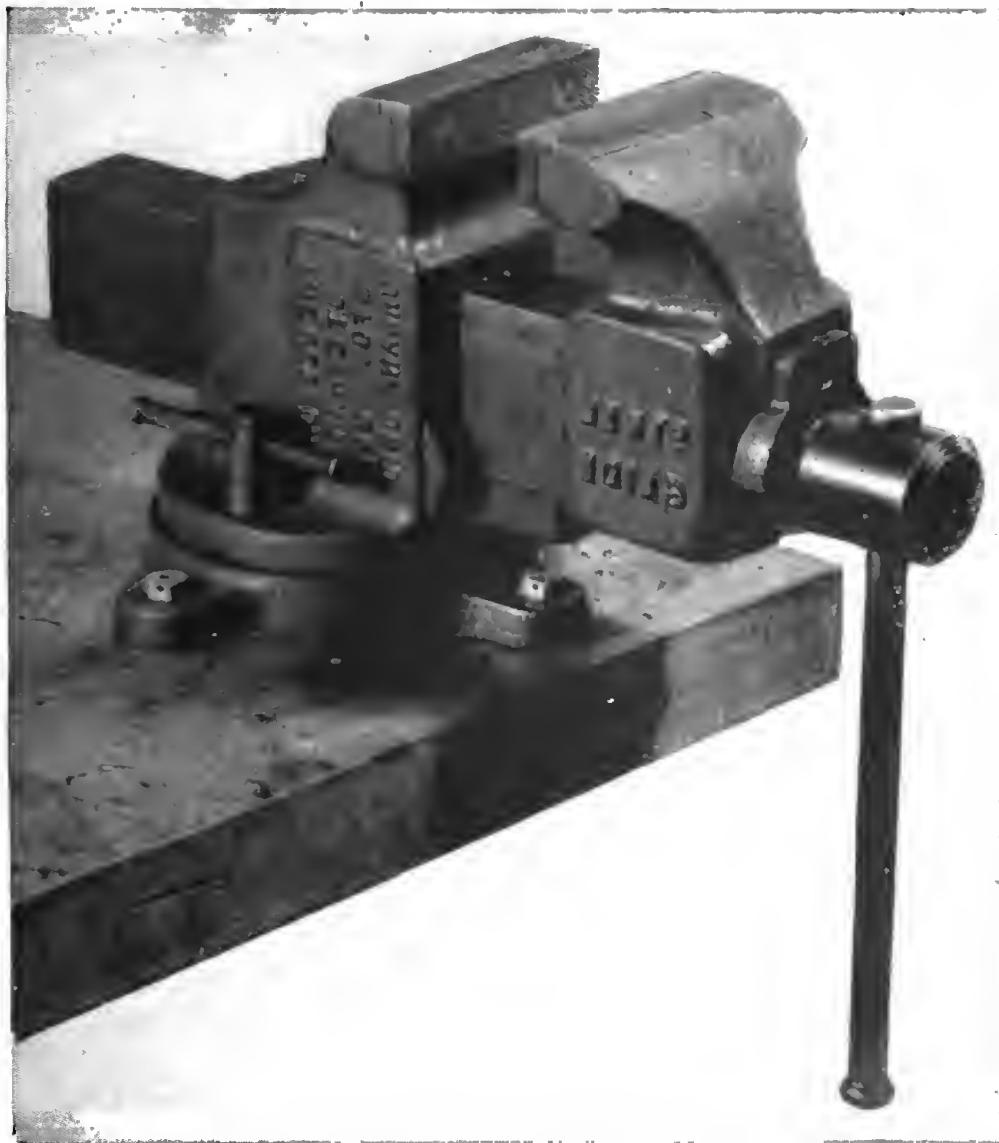


Figure 82. Bench vise.

especially difficult to hold without crushing the tube. Some mechanics have made jigs for holding tubes and other light stock that is frequently held. Figure 83 shows a jig for holding tubing in a vise.

c. WOODWORKING VISE. (1) A woodworking vise has hardwood jaws instead of steel jaws, to prevent marring the wood that is held in it. (See fig. 84.) Its use in a woodworking shop is the same as that of a bench vise in a metalworking shop.

(2) Often a woodworking vise has a quick-action feature in the tightening screw mechanism. When the screw handle is turned backward one-half turn or more, the screw is disengaged and the vise may then be pulled open or pushed shut. Turning the handle forward one-half turn engages the screw mechanism and the vise may then be tightened.

d. HANDSCREW. (1) The handscrew consists of two hardwood jaws



Figure 83. Tubing-holding jig in a vise.

and two steel spindles. (See fig. 85.) Both of the jaws are fastened to the two steel spindles. Each spindle has left- and right-hand threads on it. Rotating the spindles moves the jaws to any desired position.

(2) Handscrews are usually used to clamp glue joints, but may be used for any clamping job. The greatest advantage of the handscrew is that it may be fitted to surfaces that are not parallel.

e. CARRIAGE CLAMP. (1) The carriage clamp, or C clamp as it is commonly called, is shaped like a large "C." It has a screw with a swivel plate on it threaded through one of the bars of the "C." (See fig. 86.)

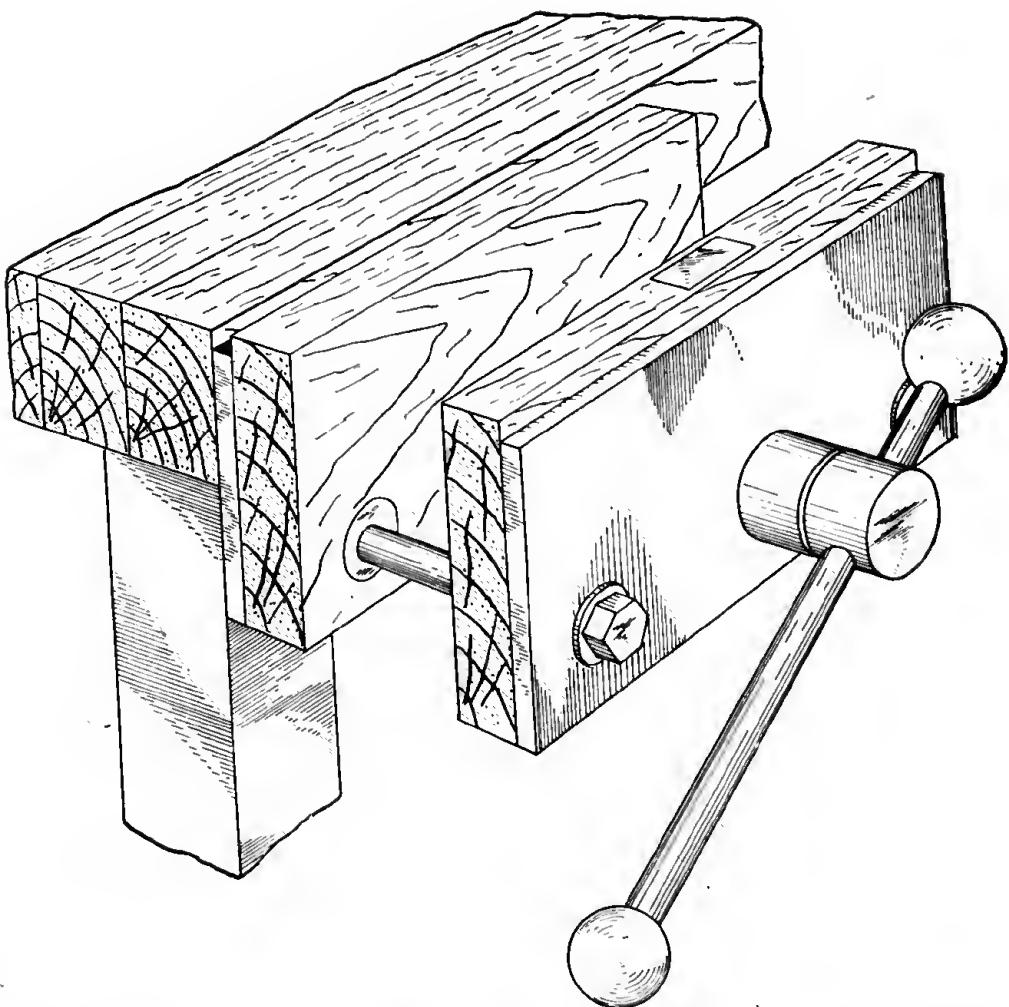


Figure 84. Woodworking vise.

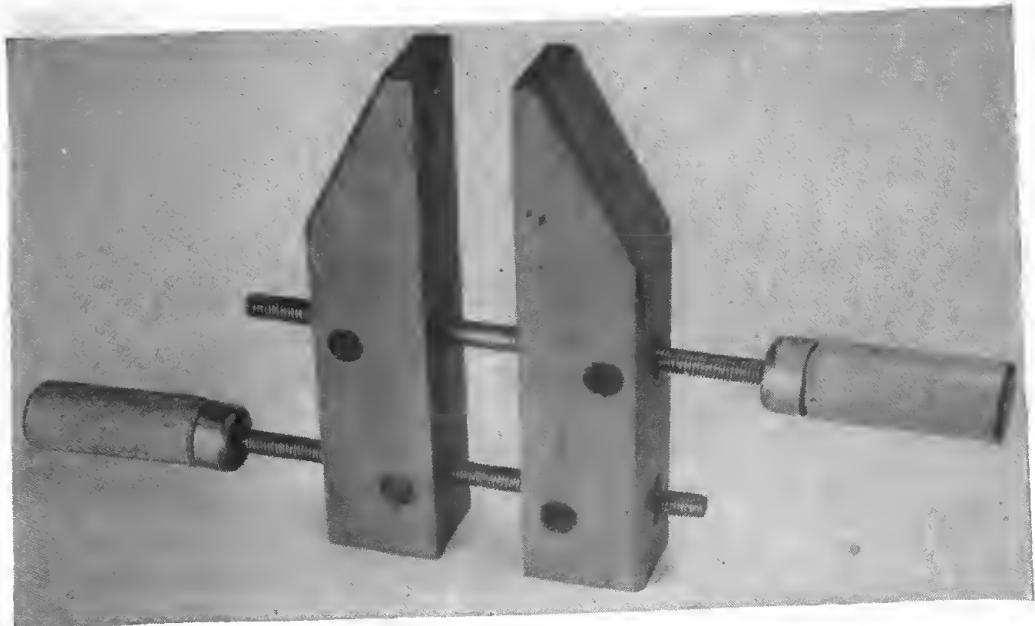


Figure 85. Hand screw.

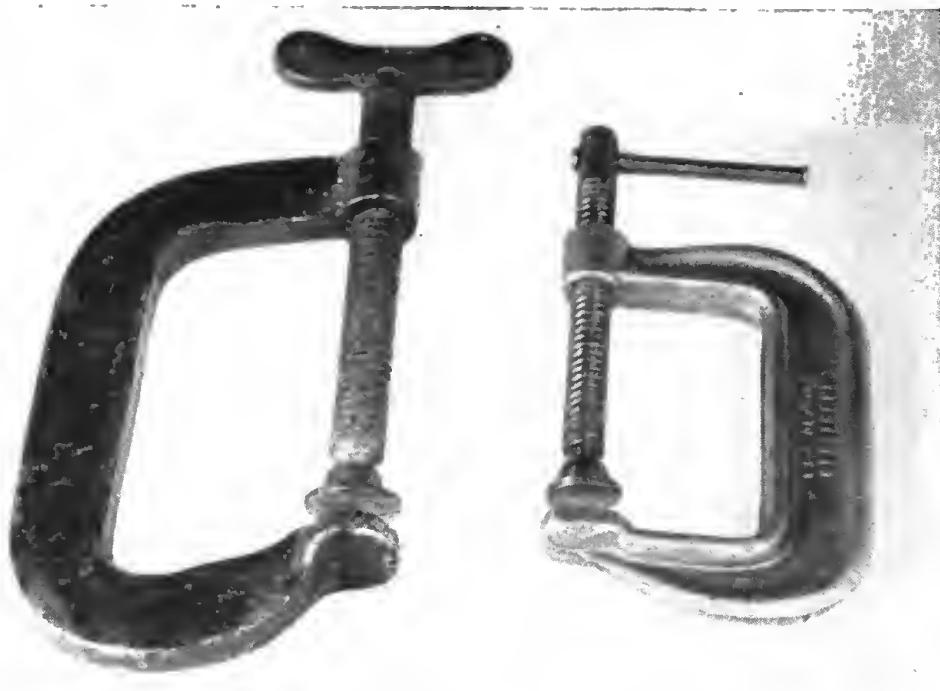


Figure 86. Carriage clamps.

The swivel plate prevents the end of the screw from turning directly against the stock being clamped.

(2) The carriage clamp may be used for almost any clamping job that is not too large and that does not require too much force. Its shape allows it to span obstructions near the edge of the work. The greatest limitation to the use of the carriage clamp is its tendency to spring out of shape. It should never be tightened more than handtight, or the sides of the clamp will spring out of shape and the clamp will be ruined.

20. Woodworking Tools

a. GENERAL. Repair work on the wooden parts of an airplane necessitates the use of woodworking tools. Here, as in other airplane maintenance, the job must be done right. A glue joint that is pretty good is not good enough; it must be perfect. One thing that will help the mechanic put out good work is sharp tools. The cutting edge of a plane blade or chisel should actually be sharp enough to shave the hair from his arm. Generally speaking, the sharper the tools, the more accurate the work will be.

b. BRACE. (1) A woodworking brace is shown in figure 87. It is used to hold the turn bits while boring holes in wood. The head and handle are usually mounted with ball bearings and should be kept lightly oiled. The chuck is the part which holds the bit. There is usually a ratchet located between the chuck and the rest of the brace to be used when working in close quarters.

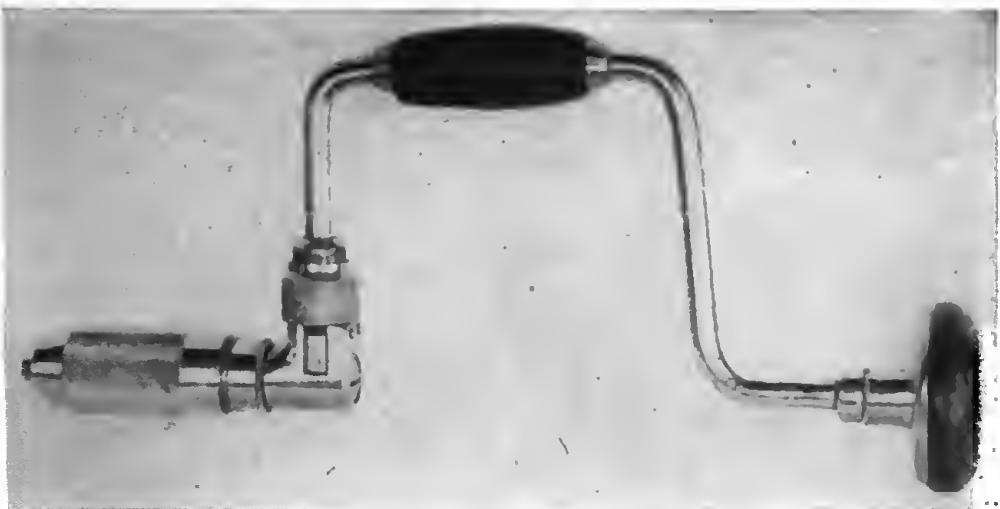


Figure 87. Brace.

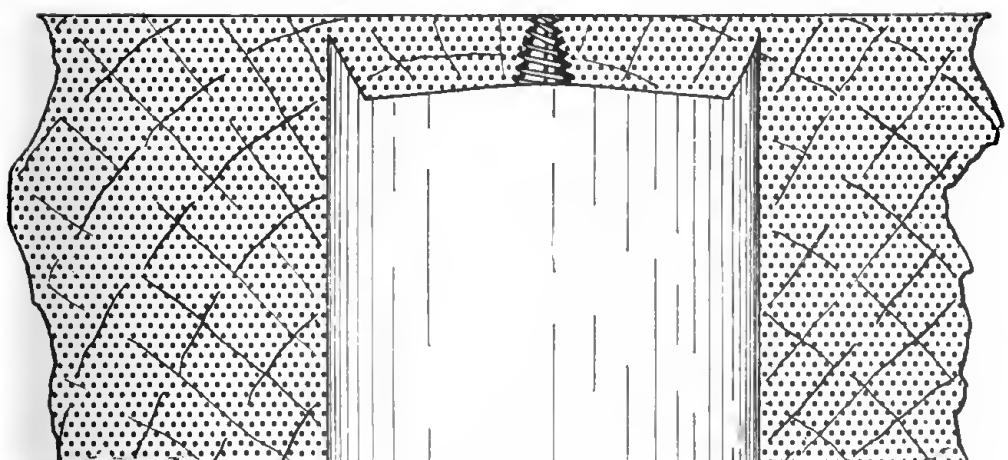
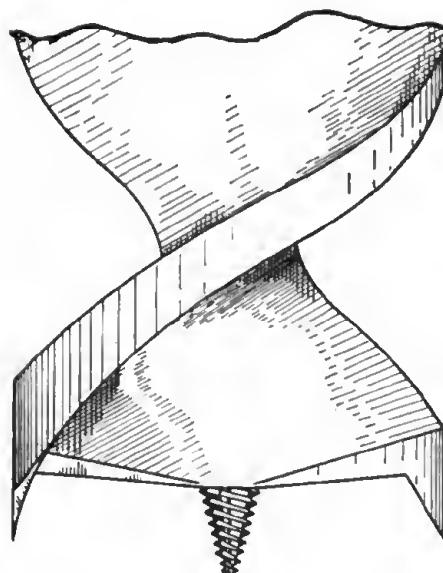
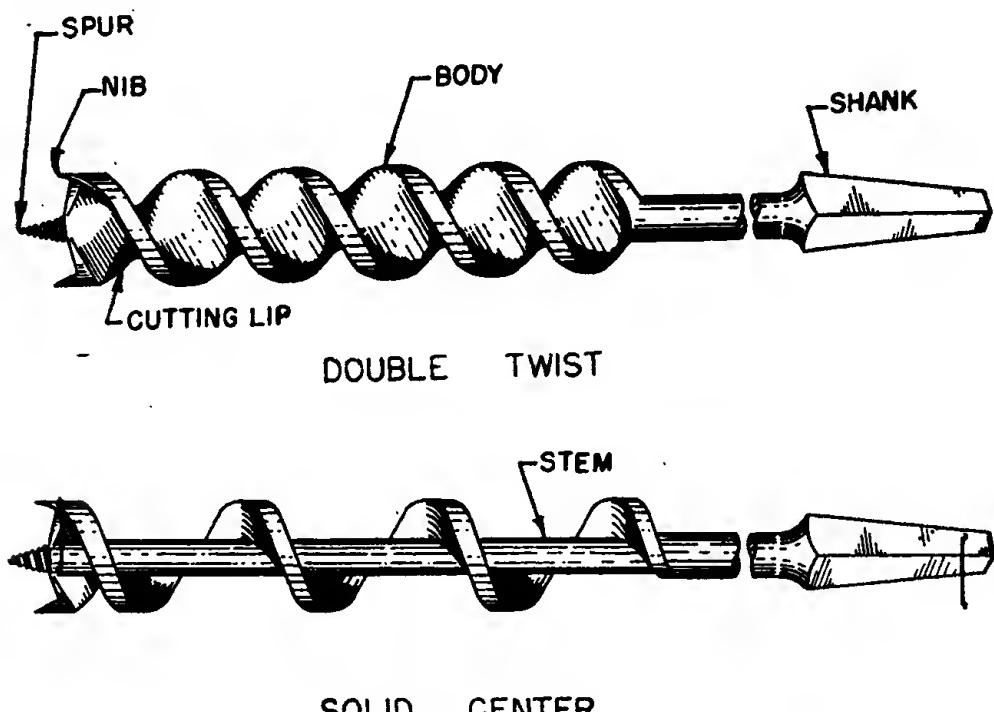


Figure 88. Method of preventing splintering when boring completely through a board.

(2) When a brace is used, care should be exercised to keep it at the proper angle to the work. If difficulty is experienced in holding the brace in the proper position, someone should stand off to the side, watching the brace, to tell the mechanic when it is out of line. The bit draws itself into the wood. Therefore, only a light pressure need be applied to the brace for most work. If too much pressure is applied, the bit will be bent. This is especially true with bits of $\frac{5}{16}$ -inch diameter and less. As the bit emerges from the work, it usually splinters the wood around the edge of the hole. This can be prevented by boring from one side until the spur comes through and then finishing the hole by boring from the other side. (See fig. 88.)

c. BITS. (1) A wood bit has a spur, two nibs, two cutting lips, a body, and a shank. (See fig. 89.) The spur has threads on it and draws



SOLID CENTER

Figure 89. Wood bits.

the bit into the wood. The nibs protrude beyond the cutting lips so that they cut the wood around the edge of the hole. This leaves a smooth surface in the hole. The body has one or two flutes through which the wood chips escape. The shank is held in the brace. A set of wood bits includes 13 bits which range in size from $\frac{1}{4}$ to 1 inch, by intervals of $\frac{1}{16}$ inch.

(2) Wood bits are used to bore holes in wood. They should not be allowed to strike nails or screws in the wood as that will damage them. If a bit does strike a nail or screw or becomes dull through use, it must be resharpened. When a bit is resharpened, the nibs are filed on the inside and the cutting lips are filed on the top with the spur pointing

down. (See fig. 90.) Filing the outside of the nibs will reduce their outside diameter, and the body of the drill will not pass through the hole cut by them. Filing the bottom of the cutting lips may remove the lip clearance and prevent the spur from pulling the bit into the wood.



① *Filing cutting lips.*



② *Filing nibs.*

Figure 90. Sharpening a wood bit.

d. COUNTERSINK. A countersink has a head which does the cutting and a shank by which it is held in the brace. (See fig. 91.) It is used to enlarge holes at the top so that flat-head screws will fit flush with the wood. If it becomes full, it can be sharpened by careful filing with a small triangle file. The lips must all be filed equally. If one lip is left higher than the others, the countersink will cut unevenly.

e. SAW. (1) Saws are classified as rip or cross-cut. The front edges of the teeth of a ripsaw are perpendicular to the edge of the saw. The front edges of the teeth of a cross-cut saw slant toward the saw edge at an angle of 60°. (See fig. 92.) A ripsaw has teeth which are similar to a series of small chisels. It is used when cutting parallel to the grain of the wood. A cross-cut saw has teeth which are similar to a series of

small knives. It is used when cutting perpendicular to the grain of the wood. When cutting at an angle to the grain of the wood, or when cutting plywood, the cross-cut saw should be used.

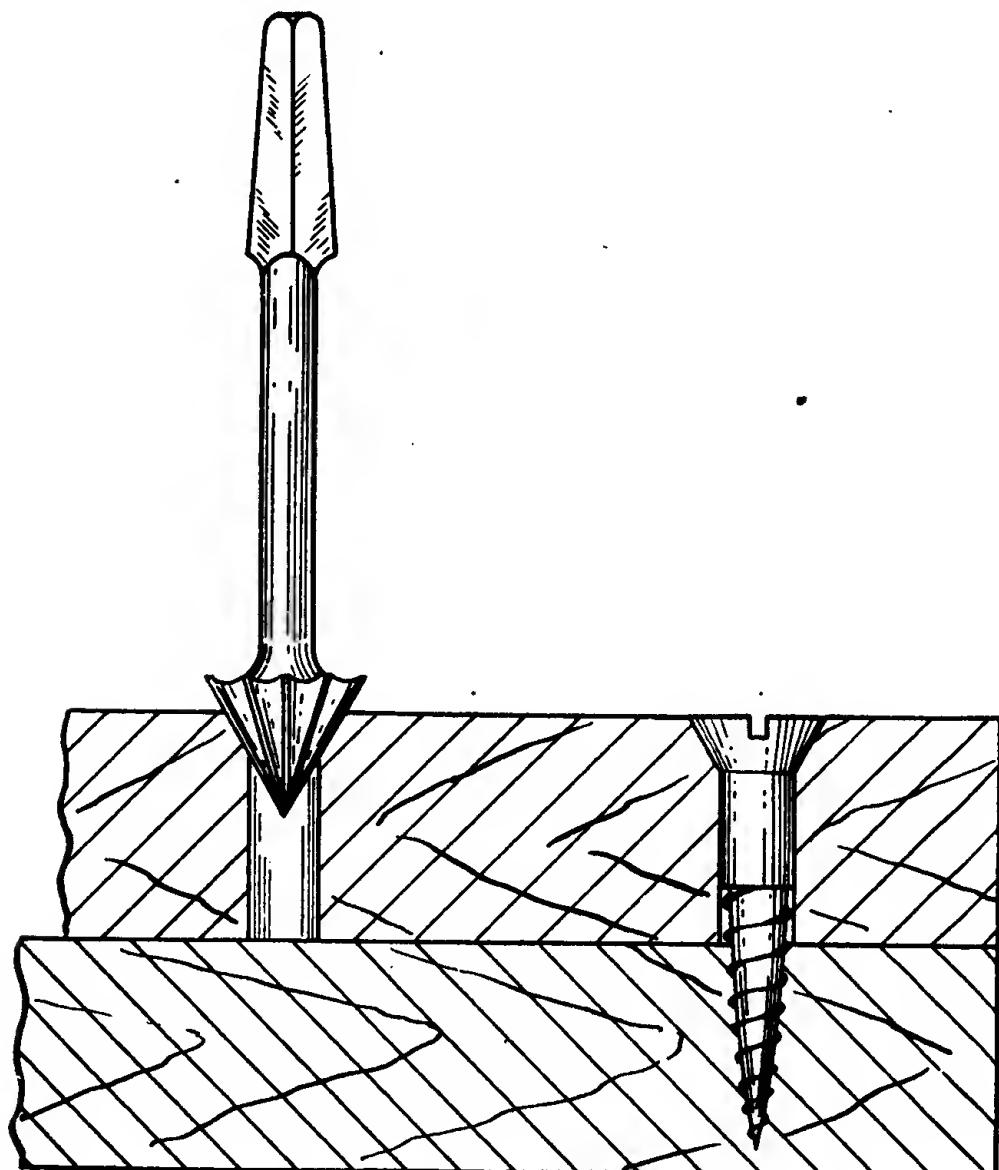
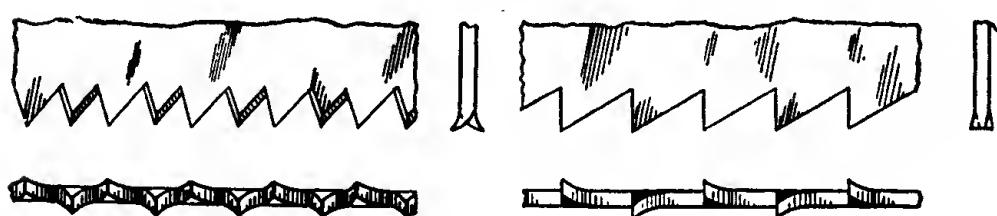


Figure 91. Countersink.



CROSS CUT

RIP

Figure 92. Cross-cut saw and ripsaw teeth.

(2) All saws have the teeth bent out a little. This is referred to as the "set." Usually every other tooth is bent to the left and the other teeth are bent to the right. This makes the cutting edges of the teeth slightly wider than the blade itself, providing clearance for the blade, reducing friction, and making the saw easier to use. Waxing the saw blade with paraffin will also make it work more easily. On wet or green wood, a saw with a great deal of set is used. On dry wood, a saw with very little set is used. A saw should have only enough to provide the necessary clearance.

(3) The grade of a saw (called the "point") is determined by the number of teeth per inch. An 8-point saw has 8 teeth per inch. A 10-point saw has 10 teeth per inch. The greater the number of teeth per inch, the smoother the cut will be. For most work on airplanes, a 12- or 14-point saw will be used. (See fig. 93.)

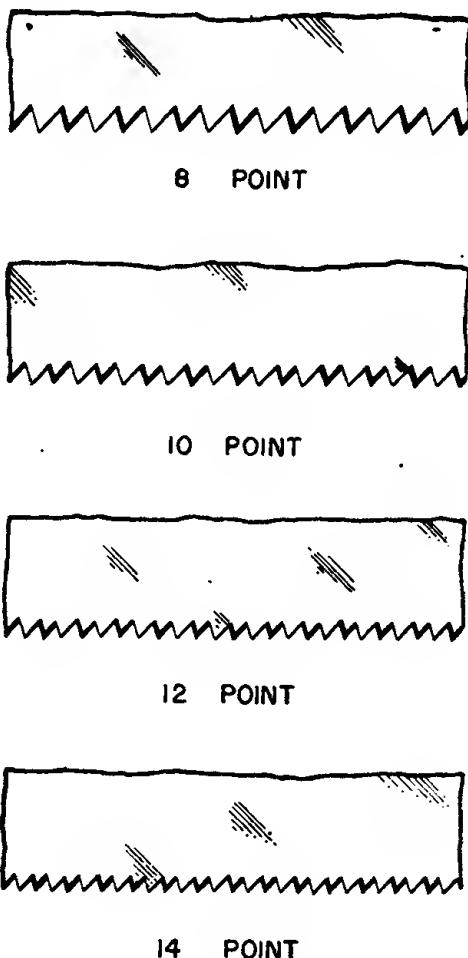


Figure 93. Size of saw teeth.

(4) To cut a board with a saw, the saw is held in line with the proposed cut and drawn back and forth with long, steady strokes. It is important that the saw be held in the proper relationship to the work or

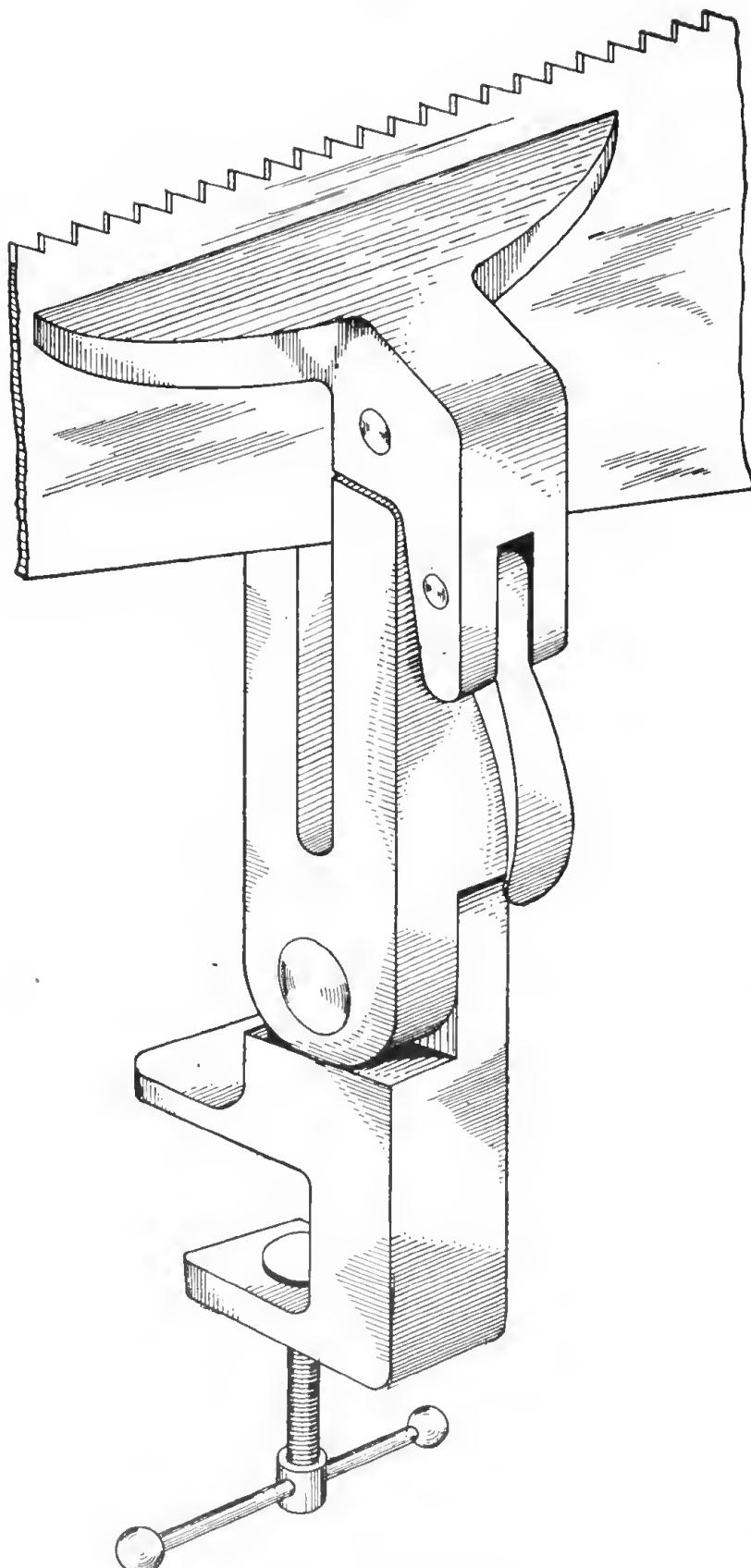


Figure 94. Saw vise.

the cut will not be in the right place. It is difficult to change the direction of the cut after the saw has entered the wood. Marking where the proposed cut is to be, all of the way around the board, will aid in starting the saw correctly. Pressure should not be applied on the pull stroke as it

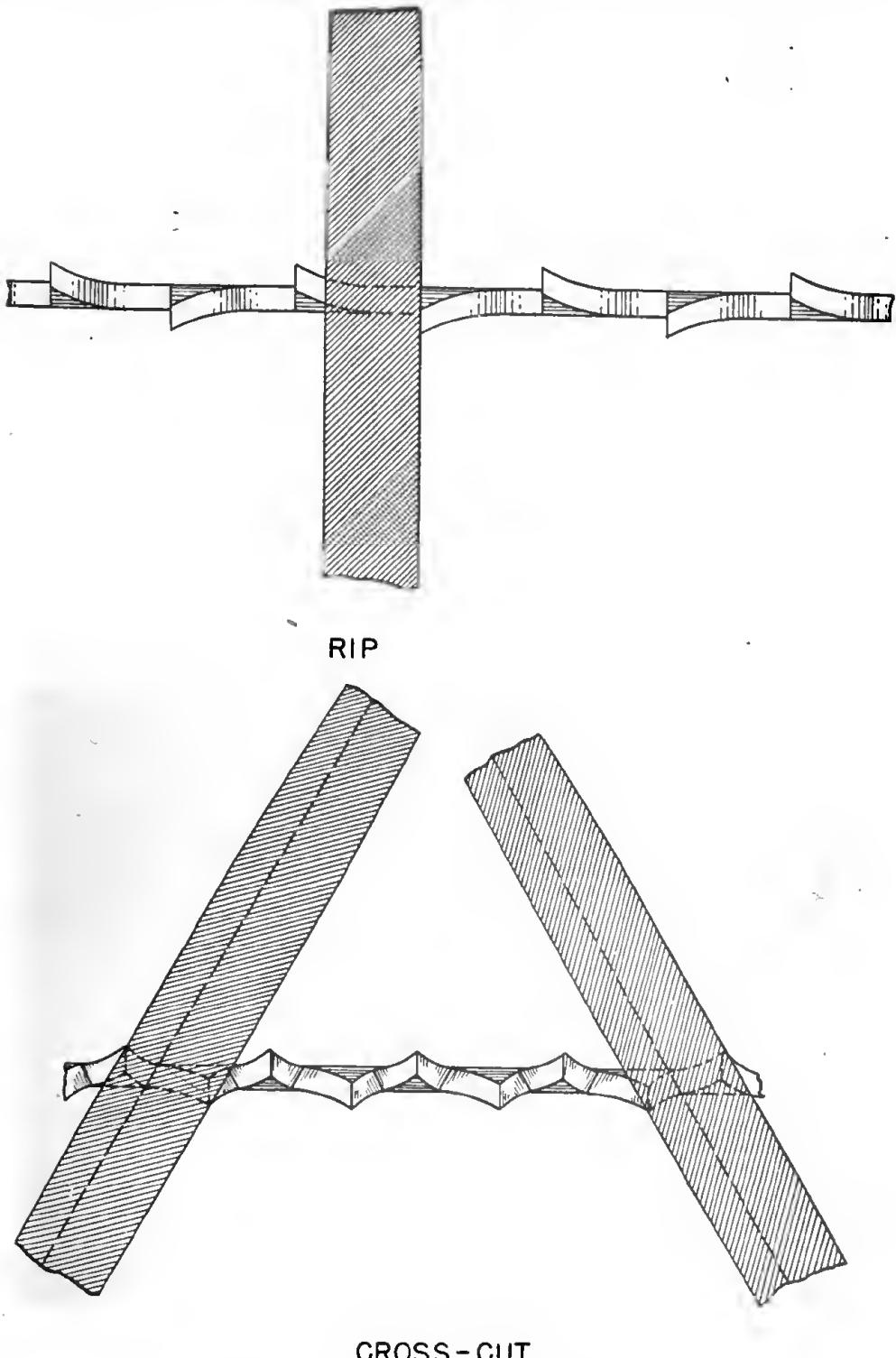


Figure 95. Position of file when filing a saw.

does not cause the saw to cut and needlessly tires the operator. Care should be taken to avoid striking nails and other pieces of metal as they damage the saw teeth.

(5) To work properly a saw must be sharp. To sharpen a saw it should be held in a saw vise. If a saw vise is not available, a bench vise may be used, but a scrap of some soft metal should be placed on each side of the saw to protect it from the jaws of the vise. The teeth of the saw should be as near the edge of the vise as possible to prevent the blade from vibrating while being filed. (See fig. 94.) If necessary, the saw should be "jointed" before being filed. This consists of filing the points of the teeth until they are all even. With the saw held securely, the teeth of the saw are filed with a saw file. Each tooth should be filed the same amount so that the top of the teeth will all be in line when the filing is completed. Ripsaws are filed straight across. Crosscut saws are filed at an angle. The file should always be held level. (See fig. 95.)

f. PLANE. (1) The frame of a plane is usually made of cast iron. Mounted in the frame at an angle to the plane bottom is the blade. The blade is made of hard steel. The plane has an adjusting screw which enables the operator to control the thickness of the cut. The common types of planes are: jointer, jack, smooth, and block. Of these, the jack and block planes are the two most commonly used. (See fig. 96.)



Figure 96. Planes.

(2) A plane is used to smooth the surface of wood and work it down to a definite size. It is usually the last tool used before making a glue joint or sanding the surface in preparation for finishing. The plane is usually held at a slight angle to the direction of movement so that the blade will have a shaving effect. (See fig. 97.) This produces a smoother surface and makes the plane easier to push. Waxing the bottom of the plane will also reduce friction and make the plane easier to push. There should be no wax on the plane bottom when making a fine cut for a glue joint. When not in use, a plane is always laid on its side. The cutting edge of the blade then touches nothing and there is no danger of dulling

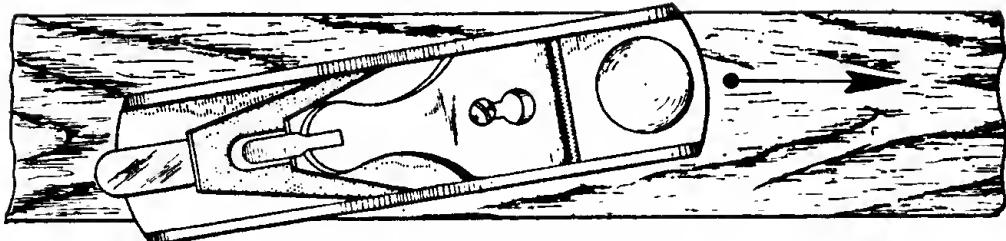


Figure 97. Position and direction of movement of a plane in use.

it. Striking nails with the blade of the plane will nick it; this should be avoided. If the edge of the blade is nicked or dulled, it should be re-sharpened.

(3) To sharpen a plane blade it should be held on an oil stone as shown in figure 98. Held in this position, it is moved around on the stone. The movement may be back and forth, circular, or figure eight, but it should cover the entire surface of the stone so that the stone will wear evenly. The rubbing against the stone should be continued until the wire edge is developed on the back of the edge. (See fig. 99.) The blade is then turned over, laid flat on the oil stone, and moved around in order to bend the wire edge the other way. It must be laid flat or the blade will have a bevel on the back and will not cut properly. (See fig. 100.) The blade is then turned over and rubbed on the beveled edge again. This

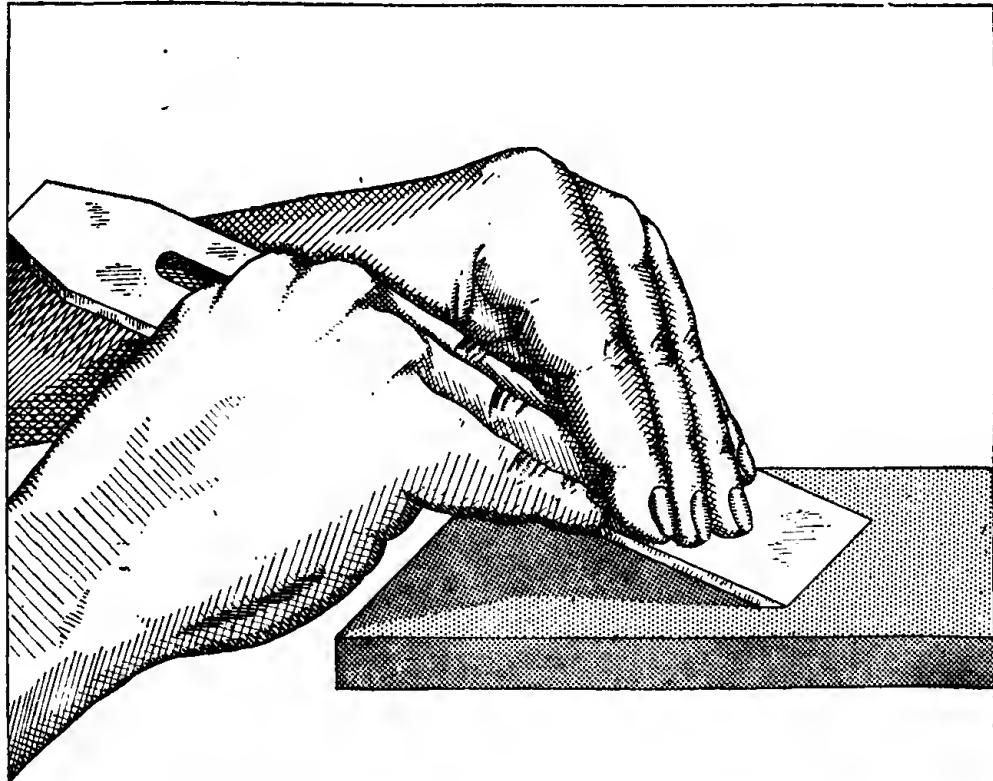


Figure 98. Sharpening a plane blade.

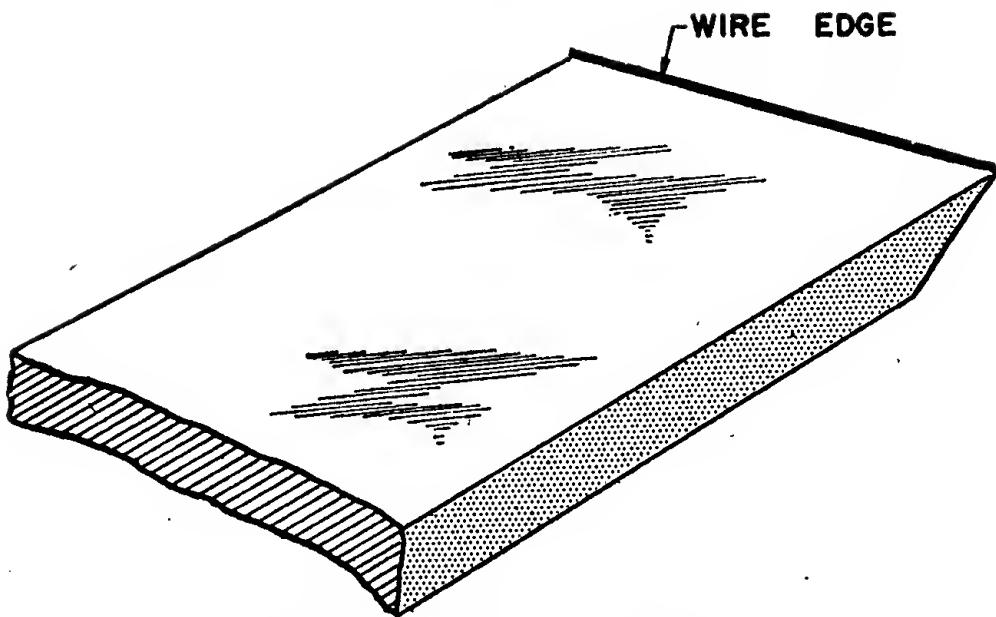
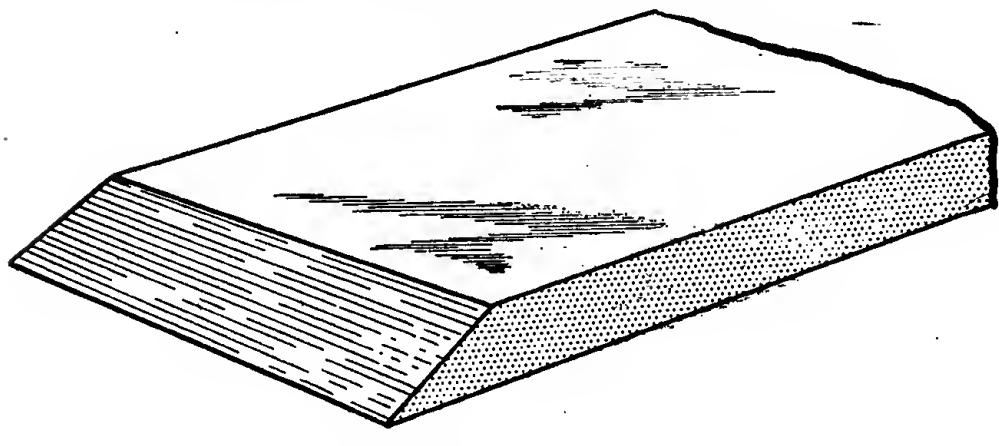


Figure 99. Wire edge (enlarged) on a plane blade.



CORRECT

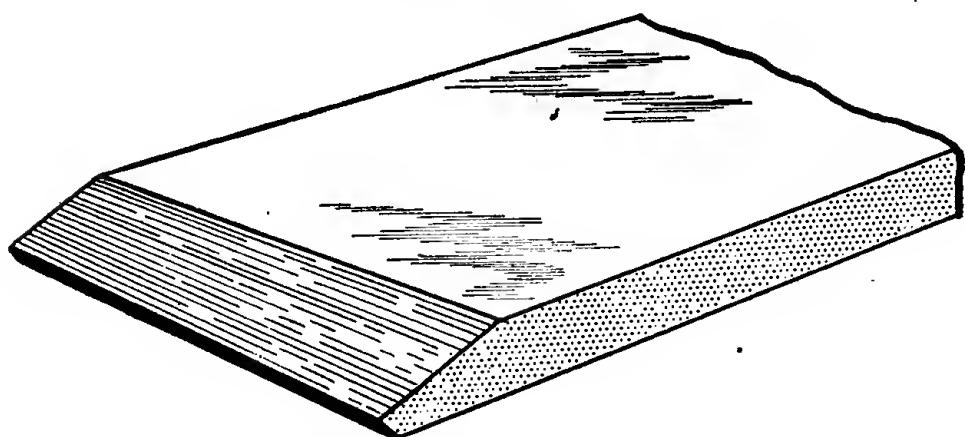


Figure 100. Result of improper sharpening of a plane blade.

turning over and rubbing is continued until the wire edge breaks off. The blade should then be sharp. Its sharpness can be tested by attempting to shave the hair on the arm with it. If it shaves, it is sharp enough. If it does not, it needs additional sharpening.

(4) After a plane blade has been sharpened several times it should be ground. It does not have to be ground, but grinding will remove some of the metal on the beveled edge and make sharpening easier. To grind the plane blade, it is held against a fine grinding wheel as shown in figure 101. It should be held at such an angle that the width of the bevel



Figure 101. Grinding a plane blade.

when finished is twice the thickness of the blade. Light pressure is applied to the blade and it is slid back and forth while grinding to insure an even edge. The blade should be dipped in water often enough to prevent burning. When finished, the edge of the blade should have a slight curve or the corners should be slightly rounded as shown in figure 102. After grinding, the blade should be sharpened.

g. CHISEL. (1) A woodworking chisel is shown in figure 103. The chisel blade is made of hard steel similar to the blade of a plane. The handle is usually made of wood. It has a leather or metal ring to prevent the wood from splintering when a mallet is used.

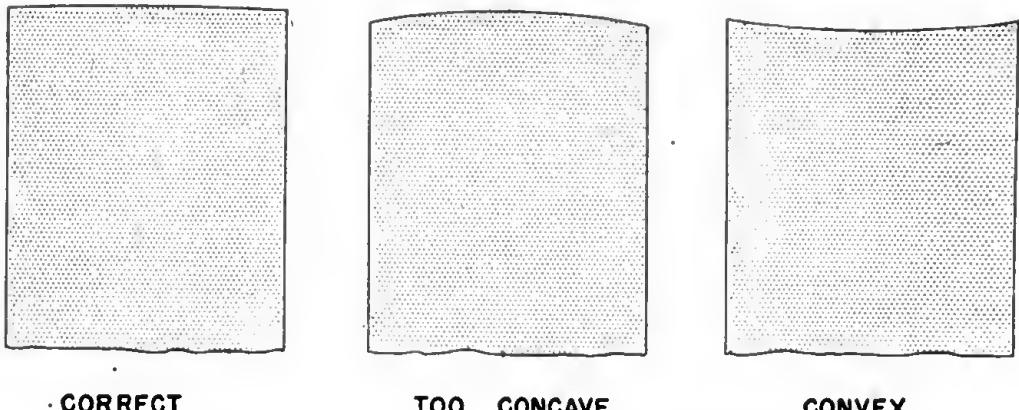


Figure 102. Correct and incorrect shape of plane-cutting edge.

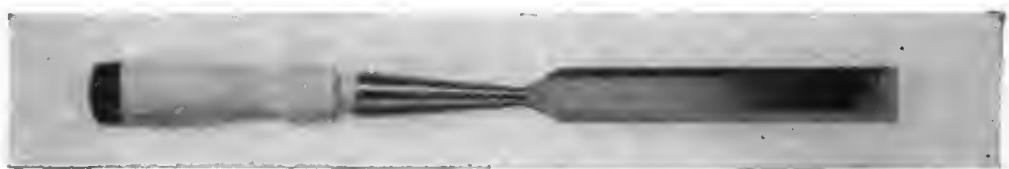


Figure 103. Woodworking chisel.

(2) A chisel is used to cut recesses in wood. Holding the chisel with the beveled edge against the wood will cause it to cut out of the work. Holding it with the beveled edge away from the wood will cause it to cut into the work. (See fig. 104.) In cutting a recess, the chisel is first held perpendicular to the wood at the edge of the proposed recess with

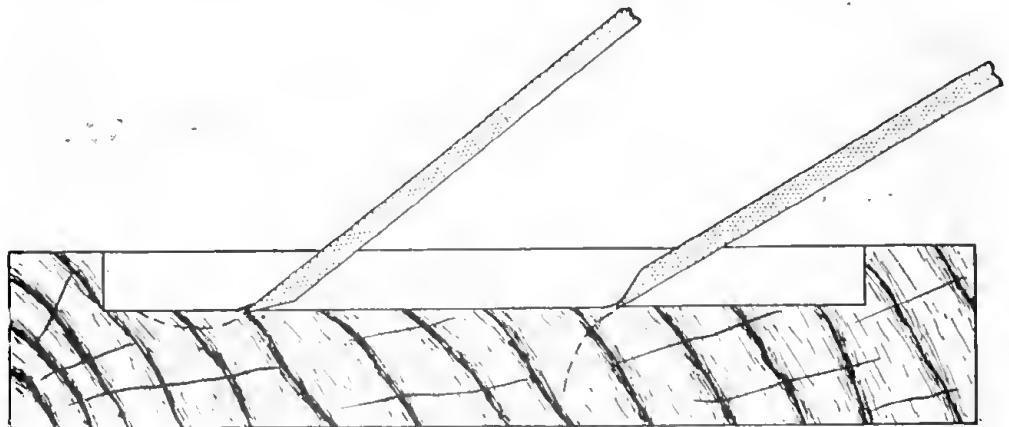


Figure 104. Effect of bevel on direction of cut.

the beveled edge toward the part to be removed, and tapped with a mallet. This cuts the wood fibers and prevents splintering. After this cut is made all the way around the edge of the recess, the wood inside is removed. Another cut is then made in the line with the first, and again the inside wood is removed. This process is repeated until the hole is as deep as desired. (See fig. 105.)

(3) A wood chisel is made to cut wood. It should not be allowed to strike metal as that will dull its edge. It should not be used as a screw

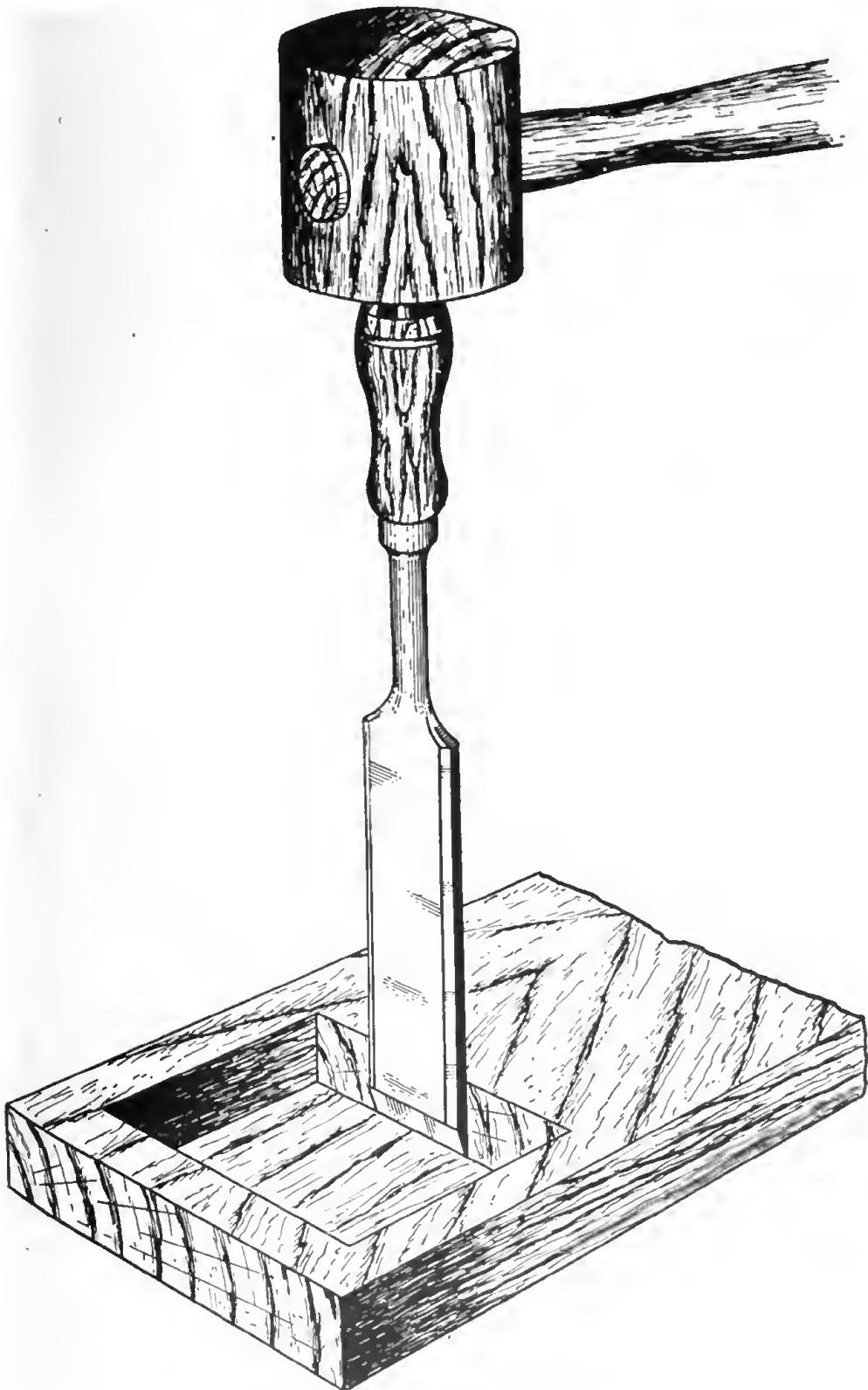


Figure 105. Chiseling a hole.

driver nor as a pry. It is sharpened and ground in exactly the same manner as a plane blade.

h. GOUGE. Gouges are made in a variety of shapes and sizes. (See fig. 106.) They are used to cut irregular recesses in wood. A mallet is not used on a gouge.

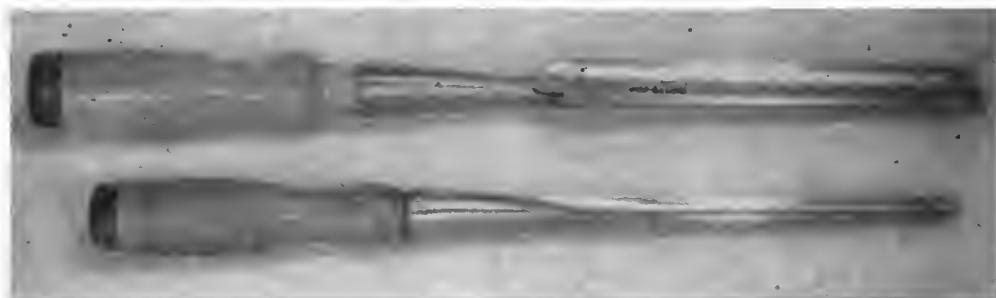


Figure 106. Woodworking gouges.

Due to their irregular shape, some gouges cannot be sharpened with an oil stone in the same manner as the chisel. For these, oil stones with various shapes are used. The principle of sharpening a gouge is the same as that for all other similar tools. A wire edge is developed, and then bent back and forth until it breaks off.



Figure 107. Pocket knife.

i. KNIFE. The knife used most frequently by the airplane mechanic will be the three-bladed pocket knife shown in figure 107. It is used for a variety of purposes. One blade is usually kept sharp and used as any other cutting tool is used. One blade is usually left dull and is used to remove insulation from electric wiring. To prevent accidents, the blades should always be closed when not actually in use.

j. RASP. A rasp is a very coarse file with the individually cut teeth. (See fig. 108.) It is used on wood as a file is used on metal. A file is sometimes used for fine work on irregularly shaped wood parts.

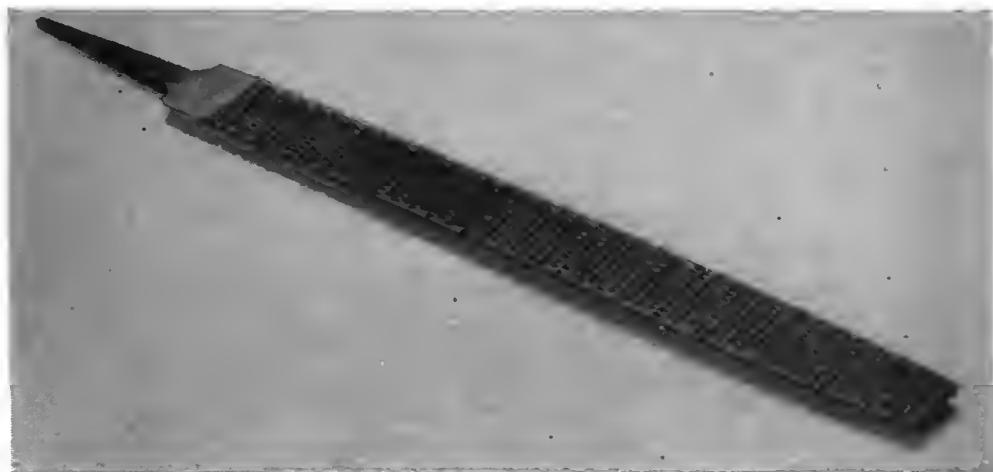


Figure 108. *Rasp.*

k. SHARPENING STONE. (1) Sharpening stones are usually made of carborundum, varying in grade from coarse to very fine. They are usually rectangular in shape, but are available in almost any shape for special work. (See fig. 109.)



Figure 109. *Sharpening stones.*

(2) Sharpening stones are used to sharpen edge tools such as plane blades, chisels, gouges, and knives. They should be coated with light oil before use to prevent particles of metal from clogging the pores of the stone and stopping the cutting action. For this reason they are fre-

quently called oil stones. A tool should not be sharpened on the same area of the stone every time. This would cause the stone to wear unevenly and reduce its usefulness. If possible, the entire surface of the stone should be used for every sharpening job. The sharpening stone is usually kept in a recess in a block of wood. This holds it while it is being used and lessens the danger of its being dropped. If dropped, the stone will probably break.

l. GLUE AND GLUING. (1) The glues used in airplane repair are: animal, blood albumin, and casein. Of these, the casein glue is most frequently used. The purpose of any glue is to hold two surfaces of wood or similar material together.

(2) To make a satisfactory glue joint, the surfaces must fit perfectly, the glue should be of the proper consistency, and enough pressure must be applied to insure close contact of the surfaces. A good glue joint is stronger than the wood itself. A poor glue joint is useless. It is important, therefore, that the mechanic prepare surfaces properly and mix and apply the glue according to the directions on the container when repairing wooden parts of airplanes.

m. SANDPAPER. (1) "Sandpaper" is a misleading name. Sand is not used. The abrasive used is either crushed quartz or garnet. Quartz paper is white. Garnet paper is red. Garnet paper is better than quartz paper because it retains its ability to cut longer. Sandpaper is furnished in grades ranging from 8/0 for final finish on lacquered surfaces to 1/2, which is the coarsest grade usually used in airplane work. The finer grades of garnet paper are waterproof and are called "wet" or "dry." They are used wet when polishing painted surfaces, to prevent the paint from clogging the sandpaper, and dry when used on wood.

(2) Sandpaper should always be held on a flat block of wood, cork, or rubber when sanding on wood. This causes it to press heavier and cut faster on the high spots and so produce a more even surface. It is usually held on the tips of the fingers when polishing painted surfaces to prevent it from cutting completely through the paint on the high spots. When sanding wood, the sandpaper should always be moved with the grain, never across the grain or with a circular movement. Sandpaper should be held so that it does not wrinkle, as wrinkling will break the abrasive off the paper and reduce its usefulness. Sanding takes a great deal of time. No definite rule can be set down as to how much sanding is necessary, but usually when the beginner thinks he has finished, the job is only about half completed.

21. Metalworking Tools

a. GENERAL. Metalworking tools are used to shape and cut metal much as woodworking tools are used on wood. They are usually heavier, harder, and have a larger angle at the cutting edge than woodworking tools, since a thin cutting edge such as is used on wood would not stand up.

b. COLD CHISELS. (1) The cold chisel derives its name from the fact that it can be used to cut metal without first heating the metal to soften it. The chisel is usually made of carbon steel. After being shaped correctly, the end of the blade is hardened by heating and quenching. The blades are made in a variety of shapes, each best suited for a specific type of work.

(2) The four most common types of cold chisels are the flat, cape, roundnose, and diamond-point. (See fig. 110.)

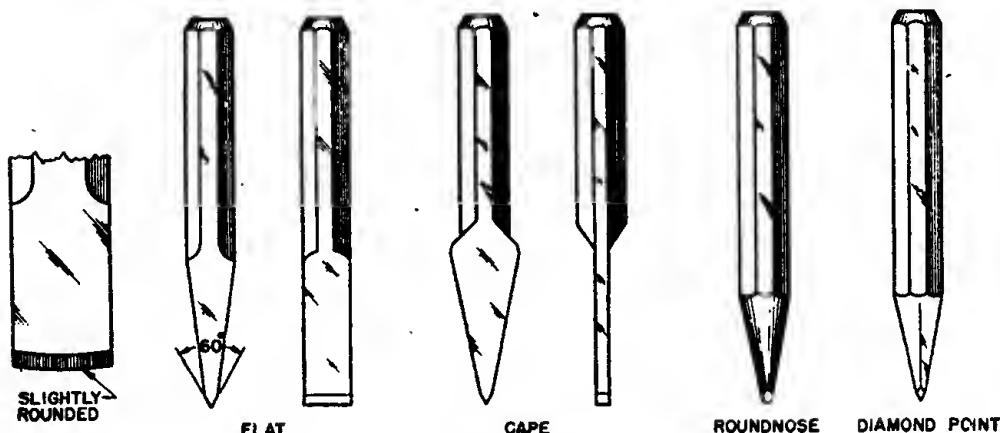


Figure 110. Cold chisels.

(3) An inexperienced mechanic usually grips the chisel with the thumb and first finger toward the head. An experienced mechanic holds the chisel with the fingers underneath and the thumb on top with the end of the first finger near the cutting edge of the chisel to aid in guiding it. (See fig. 111.) This grip will be found awkward at first, but it will also be found to save the mechanic from bruised knuckles. The cutting edge of the chisel should be kept sharp and at the correct angle for the material being worked. Sixty degrees is the right angle for most steel, about 30° for lead, and intermediate angles for metals harder than lead and softer than steel. Time spent sharpening a chisel correctly is not wasted time.

(4) It is a simple matter to sharpen a cold chisel. Hold it at the correct angle against the grinding wheel. Move it sideways while grinding. Do not press it against the wheel too hard. Dip it in water often enough to prevent overheating.

(5) With use, the head of the chisel will become mushroomed. (See fig. 112.) A chisel in this condition should not be used, as the bent-over edges are brittle and likely to break off and fly, injuring the mechanic or other personnel. To recondition a cold chisel with a mushroomed head, grind the head to the proper shape. Be sure to grind off all the cracks and rolled-over edges. Heat the head of the chisel to a cherry red and allow it to cool slowly. Only the head should be heated as heating the cutting edge will soften it and make it useless.



Figure 111. How to hold a cold chisel.

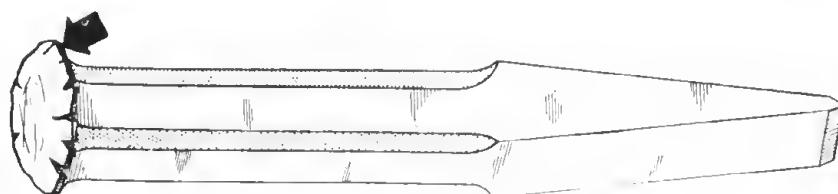


Figure 112. Mushroomed chisel head.

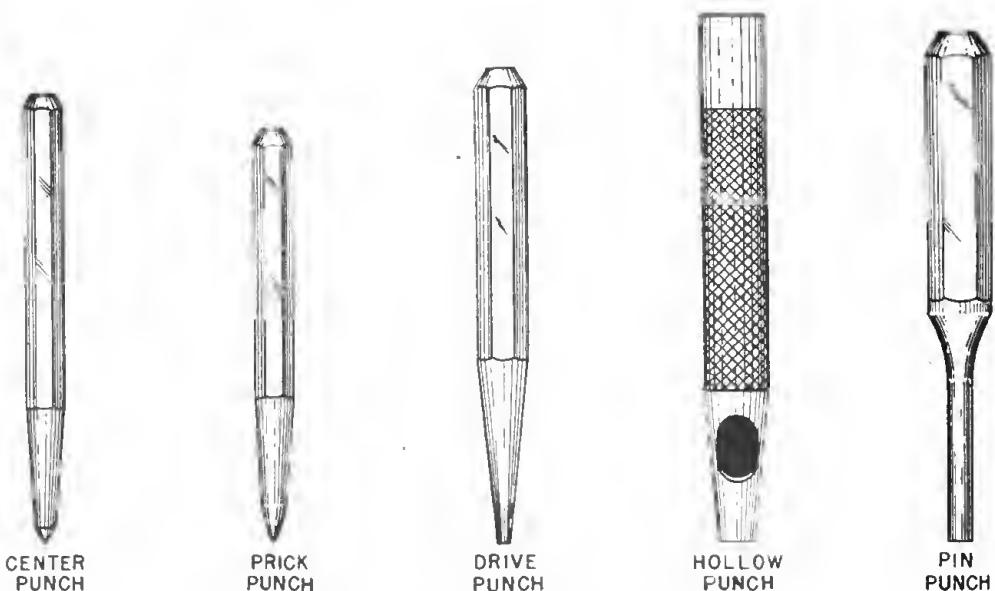


Figure 113. Types of punches.

c. PUNCHES. (1) Punches are made of the same material, in the same manner, and require the same care as cold chisels.

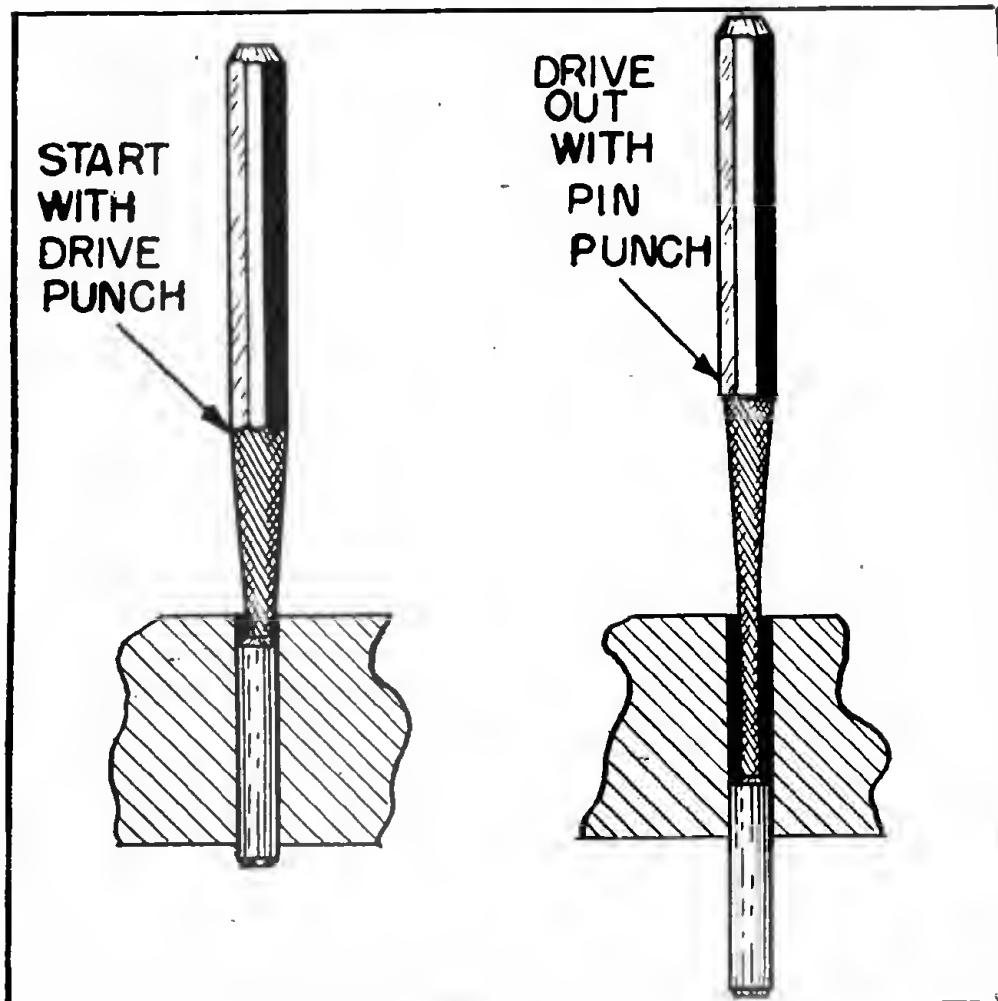
(2) The five types of punches used by the airplane mechanic are: prick, center, drive, drive-pin, and hollow. (See fig. 113.) The work for which they are best suited depends upon their shape.

(3) Prick punches are used to place reference marks on metal. They are relatively slender and are tapered to a point of about 30° . A prick punch should never be struck a heavy blow with a hammer as that is likely to bend the punch or dull the point.

(4) Large indentations in metal such as are necessary to start a twist drill are made with a center punch. It has a heavier body than a prick punch and is ground to a point with an angle of 60° .

(5) As the name implies, a drive punch is used to drive pins and bolts out of holes in which they sometimes bind. The drive punch is therefore made with a flat face instead of a point.

(6) Drive-in punches are similar to the drive punches and are used for the same purposes, the difference in the two being that the sides of a



Proper use of drive and drive-pin punches.

drive-pin punch are parallel for the last inch or so, whereas the sides of a drive punch taper all the way to the face. In general practice, a pin which is to be driven out is usually started with a drive punch and driven until the sides of the punch touch the edge of the hole. A drive-pin punch is then used to drive the pin the rest of the way out of the hole. Particularly stubborn pins may be started by placing a thin piece of scrap copper, brass, or aluminum directly against the pin and then striking it with a heavy hammer until the pin begins to move. The other operations are the same as with ordinary pins. A prick punch or center punch is never used to remove pins as the point of the punch will spread the pin and cause it to bind even more.

(7) Hollow punches are usually used to cut holes in light material such as gaskets, but may be used to cut holes in thin, soft metals. To cut a hole with a hollow punch, place the work on a flat, hardwood block.

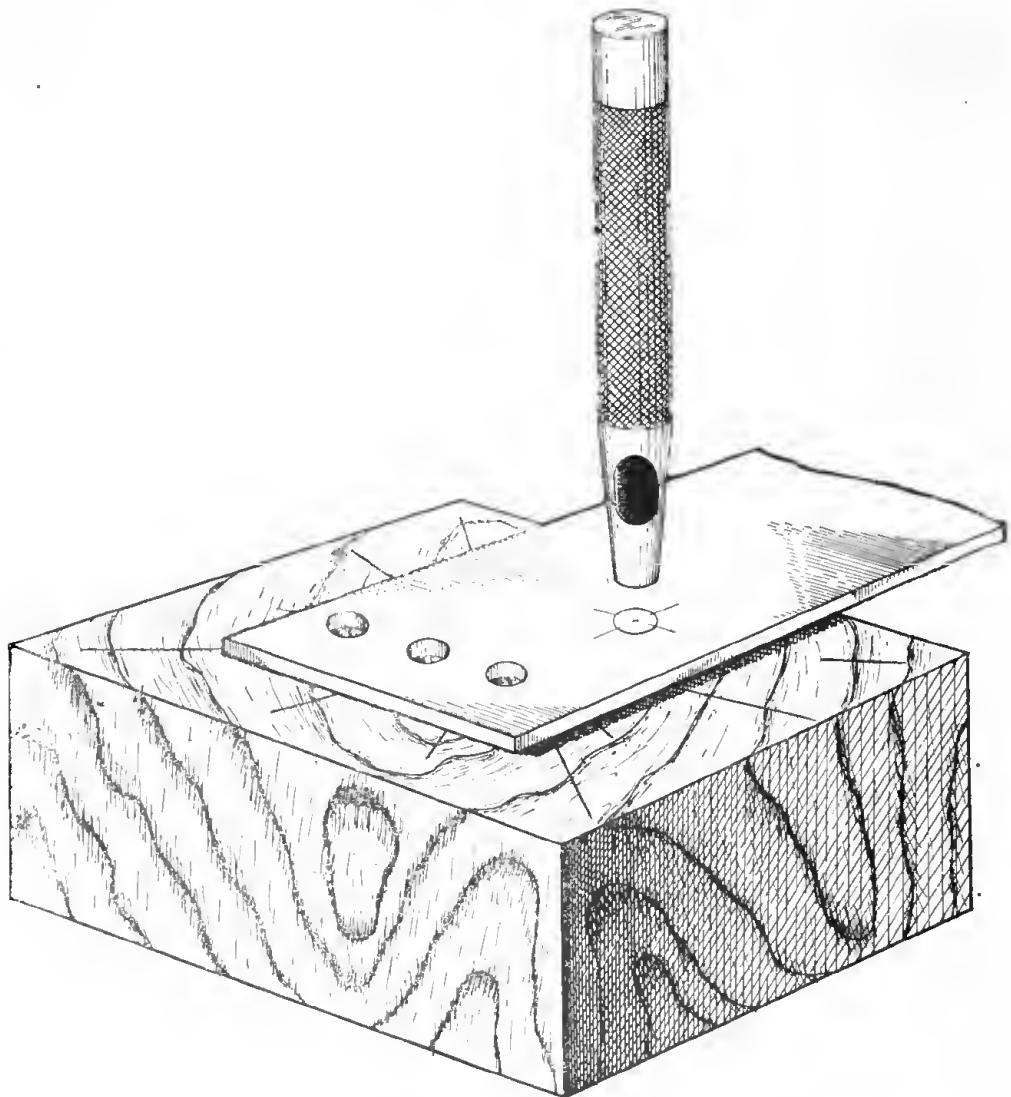


Figure 114. Cutting a hole with a hollow punch.

Locate the punch on the exact spot where the hole is needed. (See fig. 114.) Hold the punch perpendicular and strike it with a heavy hammer.

d. FILES. (1) Files are used in fabricating parts and for filing parts to fit. Skilled mechanics with the right file can and do work metal to within a tolerance of $\frac{1}{1,000}$ inch. Files consist of the following parts: tang, blade, heel, and point. (See fig. 115.) Files are made in a variety of

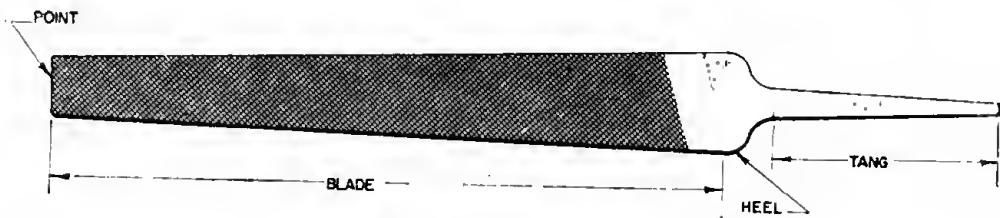
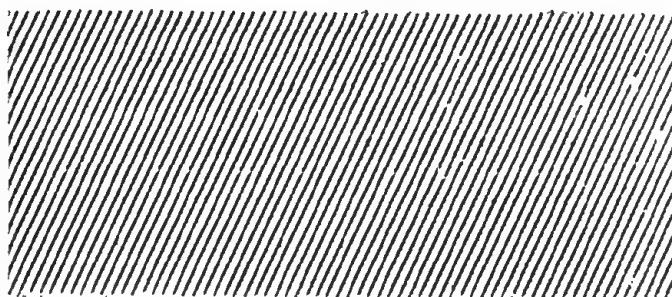
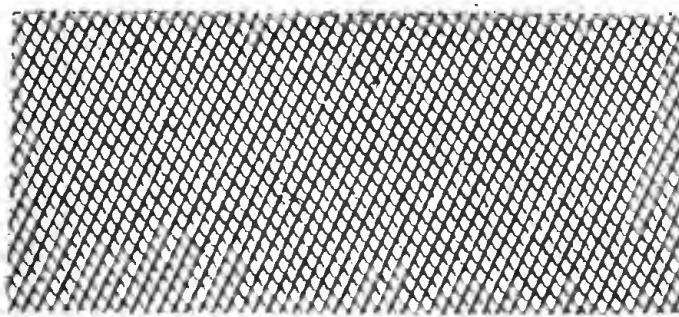


Figure 115. Parts of a file.

shapes and sizes but the method of manufacture is the same for all of them. A file blank of carbon steel is heated, the teeth are cut into it, and it is quenched in water to harden it. The hardening process also makes it brittle, which is a disadvantage, but it cannot be avoided. A magnified picture of file teeth is shown in figure 116.



① Single cut.



② Double cut.

Figure 116. Magnified picture of file teeth.

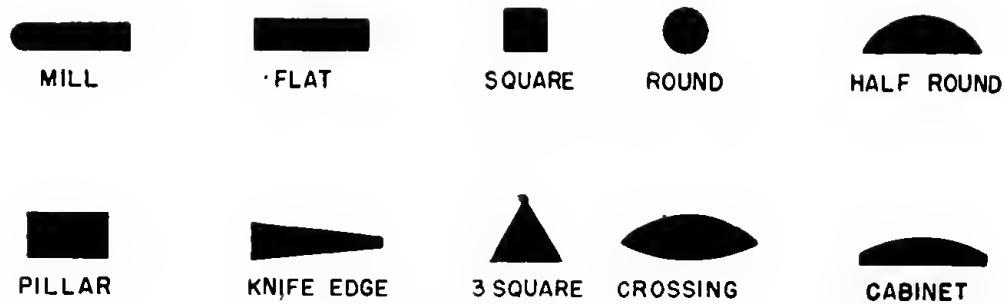
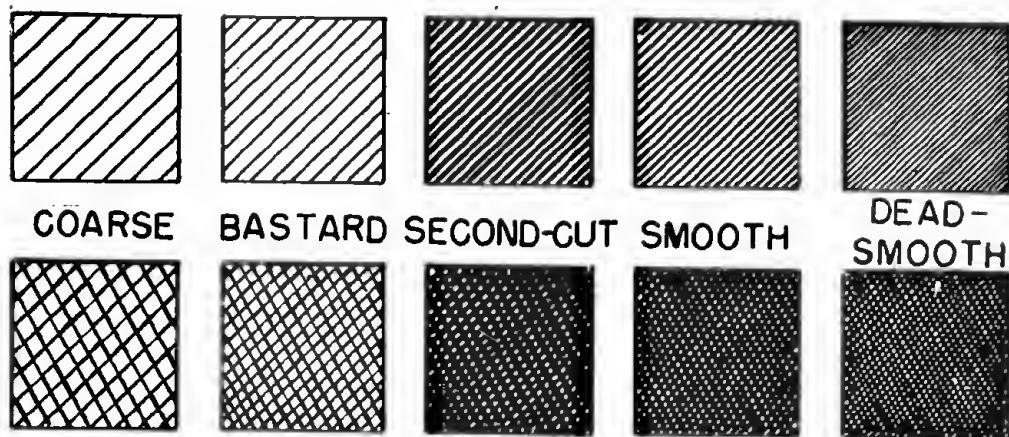


Figure 117. Shapes of files.

SINGLE - CUT



DOUBLE - CUT

Figure 118. Grades of files.

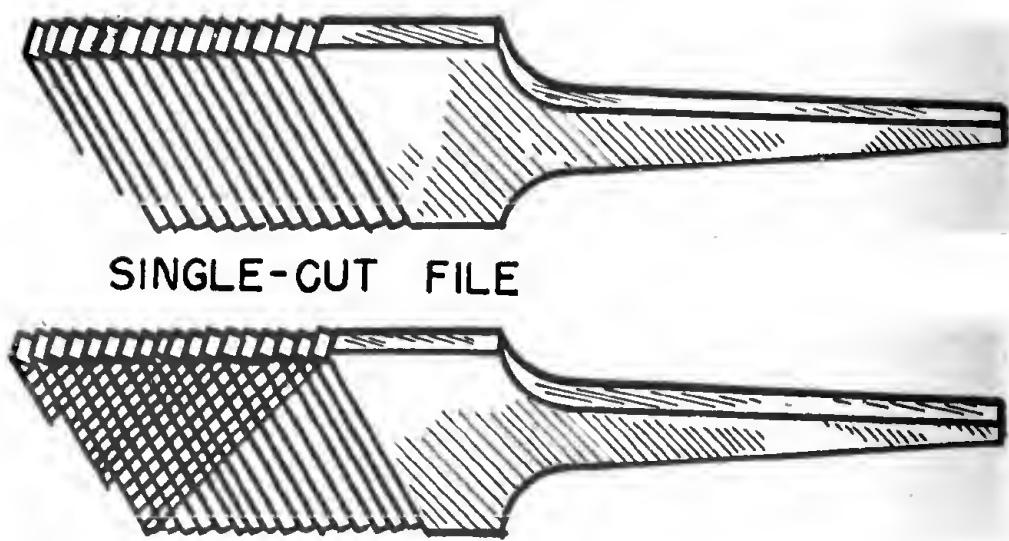


Figure 119. Single-cut and double-cut files.

(2) Some examples of various cross-section types are: mill, flat, square, round or rat-tail, triangle, knife-edge, half-round crossing, and cabinet. (See fig. 117.) The common grades of files are coarse, bastard, second-cut, smooth, and dead-smooth. (See fig. 118.) The cut of a file refers to the number of rows of teeth. A single-cut file has one row of chisel-shaped teeth set at an angle to the center line of the file. A double-cut file has a second row of cuts at an angle to the first row, leaving the teeth smaller and diamond shaped. (See fig. 119.)

(3) The file chosen for any particular job depends upon the material being worked and the finish desired. For soft materials, use a coarse file. For hard materials, use a fine file. For a very accurate finish, use a very smooth file. For rougher work, use a coarser file.

(4) The handle of a file should be held (by a right-handed filer) in the right hand with the fingers underneath and the thumb on top. The left hand should grip the point of the file between the palm and fingers. This will give the mechanic greatest control of the file. For very accurate finishes, the thumb and fingers of the left hand should rest on top of or lightly grip the point of the file. (See fig. 120.) If possible, the work should be at the height of the mechanic's elbow. The strokes with the file should be as long and smooth as possible. There should not be more than 60 strokes per minute. If a file is used too fast, it will actually cause the points of the teeth to get hot enough to lose their hardness. There should be no pressure on the file as it is being drawn back. The teeth slant for-



①

Figure 120. How to hold a file.



②

Figure 120. How to hold a file.—Continued

ward and pressure on the back stroke will break them off much more readily than on the forward stroke. There is one exception to the above rule. When filing very soft metals such as babbitt or aluminum, the file should have a slight pressure applied on the back stroke. The metal is soft and will not break the teeth and the slight pressure aids in cleaning the file.

(5) Files often pick up chips which stick tightly in the teeth. This is called pinning. When this happens, the file may be cleaned with a file card (fig. 121) or even a sharp-pointed pick. A little oil or chalk on the file, especially a new one, will help prevent pinning. A new file should not be used on very hard metals, nor should very much pressure be applied to it at first. A few heavy strokes on a hard material will take several hours from its useful life. Files are usually cleaned with a file card, but wood and fiber chips can be removed more easily if the file is dipped in alcohol or gasoline, burned, and then cleaned in the usual manner with a file card. Particles of wood should not be burned out with a blowtorch as this heats too hot and draws the temper. The file should be well-oiled immediately after burning, to prevent rusting. A file should never be used on a material harder than itself or on scaly castings. This will break the teeth and make the file useless. A file should never be tossed or thrown into a drawer; nor should it be laid on other files. The best place to keep a file is standing upright with the tang in a hole. If it must be kept in a drawer or tool box, it should be kept wrapped in paper or cloth. The surface of a file blade is made up of thousands of small teeth. It is these teeth which do the work. If they are broken or dull, the file is useless.

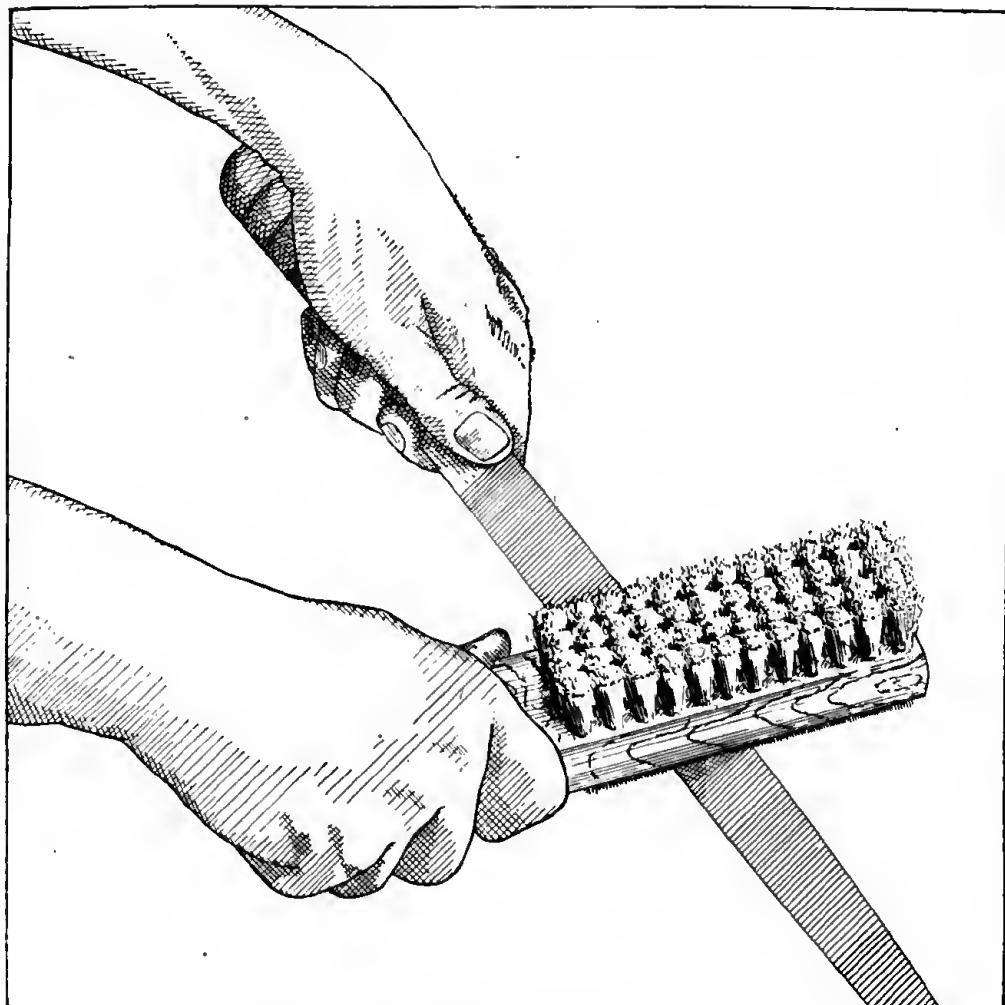


Figure 121. Cleaning a file with a file card.

The file should be kept oiled to prevent rusting. This is especially true in damp climates.

(6) A file should never be used without a handle. It is not only more difficult to control, but also likely to cut the mechanic's hand. Figure 122 shows how to attach the handle to the file. The handle should be tight. Never salvage a file to make a punch or knife. The metal is far too brittle for this purpose. Never use a file as a pry or hammer. It will probably break, throwing off small, sharp bits of steel.

e. DRILLS AND DRILLING. (1) When making installations to comply with changes in Technical Orders and when patching the airplane skin, the airplane mechanic needs to be able to use and sharpen twist drills properly. A drill is in figure 123. The lips are the parts which actually do the cutting. The flutes allow the chips to escape and give the correct rake to the cutting lips. The body of the drill is ground away slightly except at the margin to reduce the friction of the drill as it rotates.

(2) When laying out work to be drilled, a small prick-punch mark

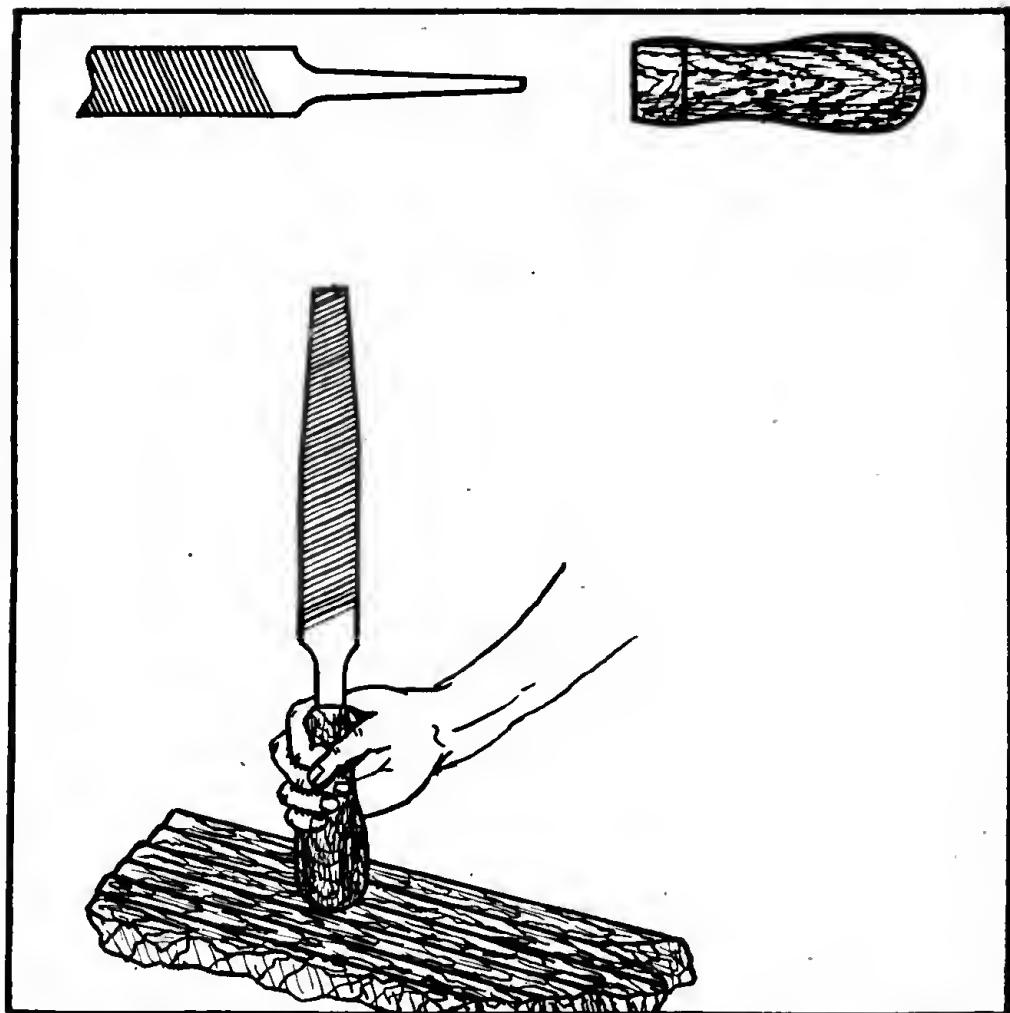


Figure 122. Method of mounting handle on a file.

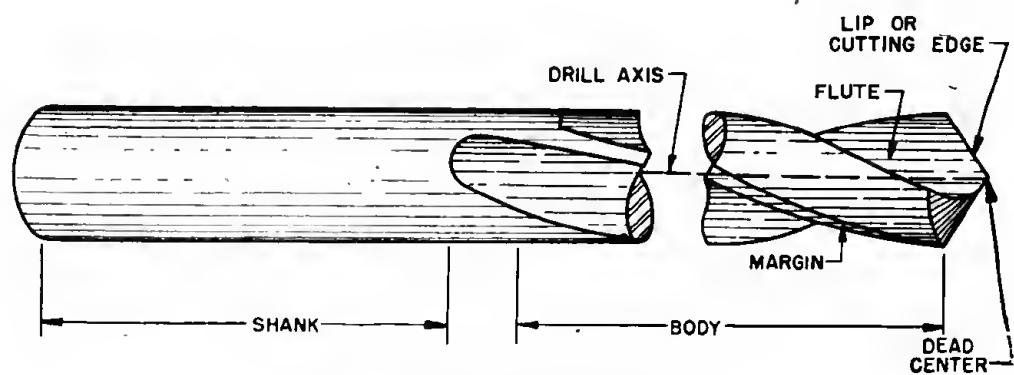


Figure 123. Parts of a drill.

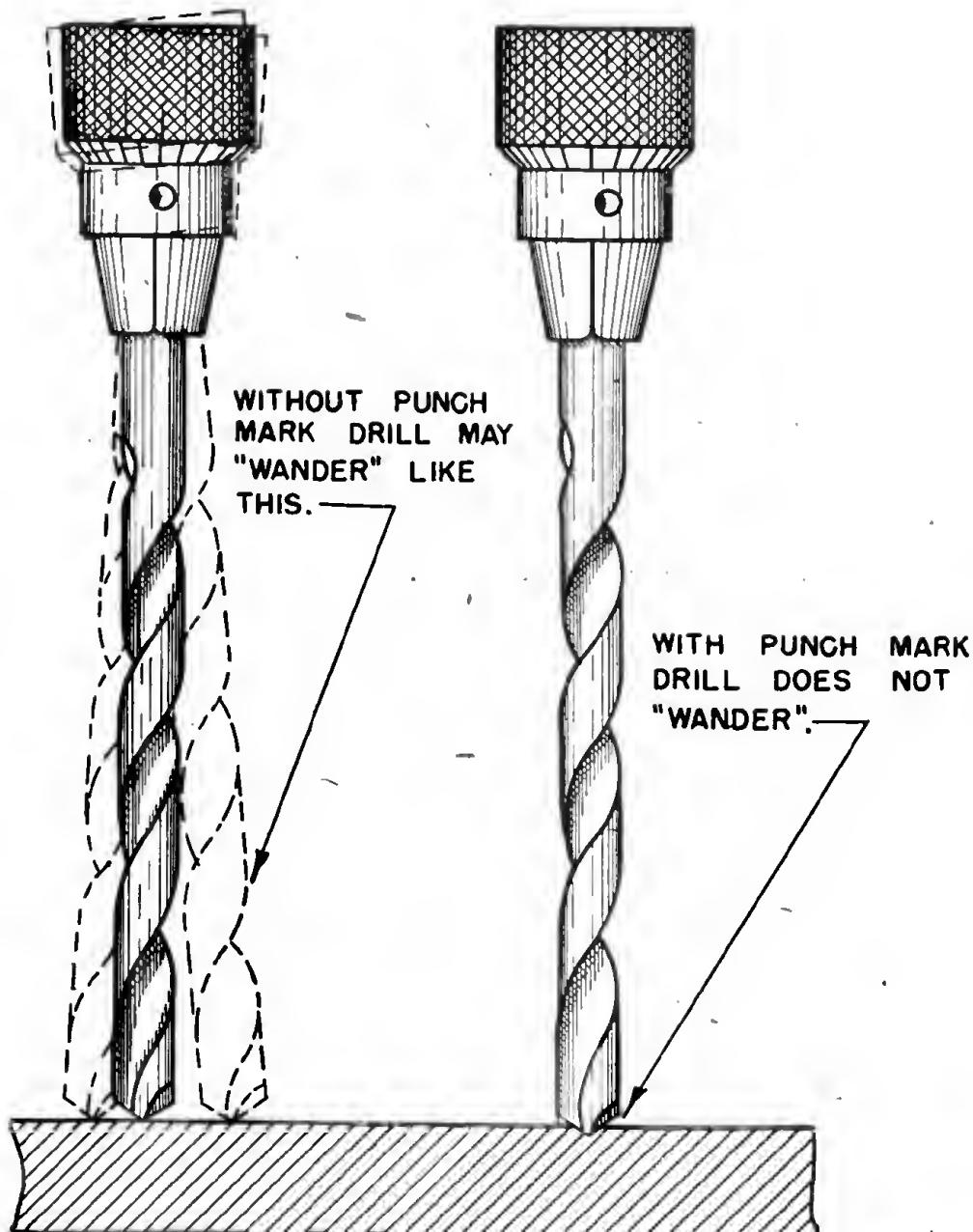
should be placed in the exact center of where the hole is to be drilled. One or more graduated circles should then be drawn with this point as the center. The largest of these circles should be equal to the hole that is to be drilled. The center mark should then be enlarged and deepened with



Never use a file without a handle.

a center punch. The point of the drill is then placed in the center-punch mark. The drill is held perpendicularly to the mark. A little pressure is applied. The amount of pressure depends on the size of the drill and the hardness of the material. The drill is rotated. If the hole is to be drilled completely through the stock, the pressure should be lessened as the point of the drill begins to emerge. This prevents the drill from catching on the chips as the drill breaks through the stock.

(3) As soon as the center-punch mark has been cut away, remove the drill and check to make sure that the hole is in the exact center of the circles. If it is not, the drill can be made to lead in any direction desired by cutting a groove in the side of the drilled portion with a cold chisel.



Always punch-mark work before drilling.

(See fig. 124.) The drill cannot be made to lead after the entire point has entered the work.

(4) It is sometimes necessary to enlarge the hole for part of its depth. This is called counterboring. The counterboring tool has a pilot on the point so that the center of the large hole will be in line with the center of the small hole. (See fig. 125.) Enlarging the top of a hole so that a flat-headed screw will fit flush with the surface is called countersinking. No pilot is necessary for countersinking.

(5) With use, the cutting edge of the drill is dulled and must be re-

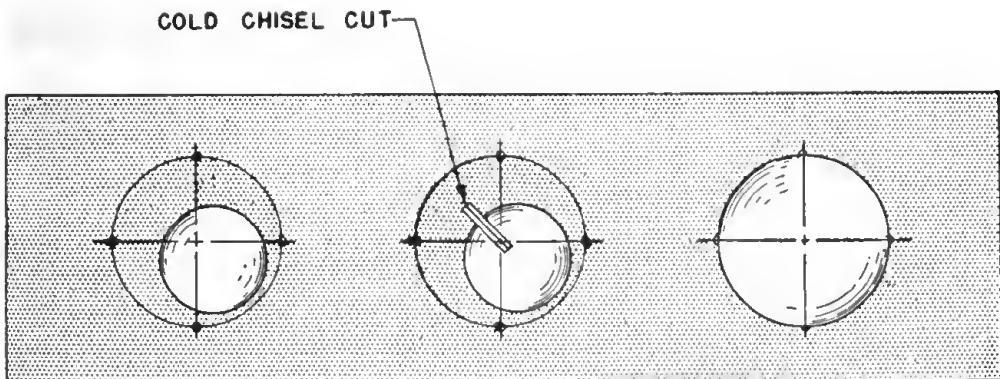
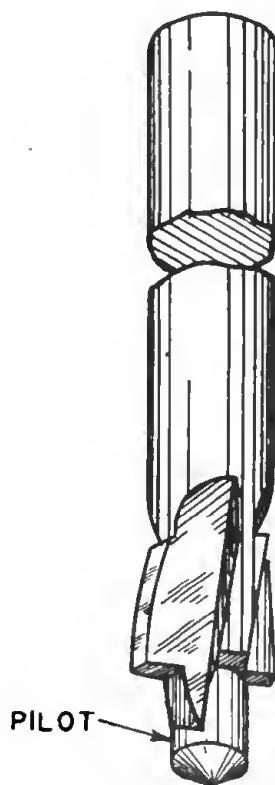


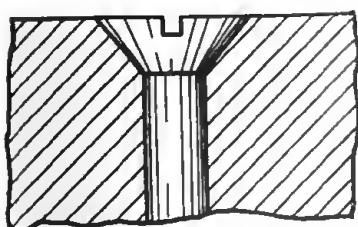
Figure 124. Leading a drill.



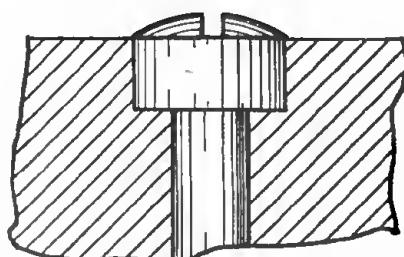
COUNTERSINK



COUNTERBORE



FLATHEAD SCREW IN
COUNTERSUNK HOLE



FILLISTER HEAD SCREW
IN COUNTERBORED HOLE

Figure 125. Counterbore and countersink.

sharpened. It is important that this be done correctly if the drill is to cut properly. Sufficient time should be taken to be sure that job is done right. For general work, the cutting lips (fig. 126) must be of equal length, have

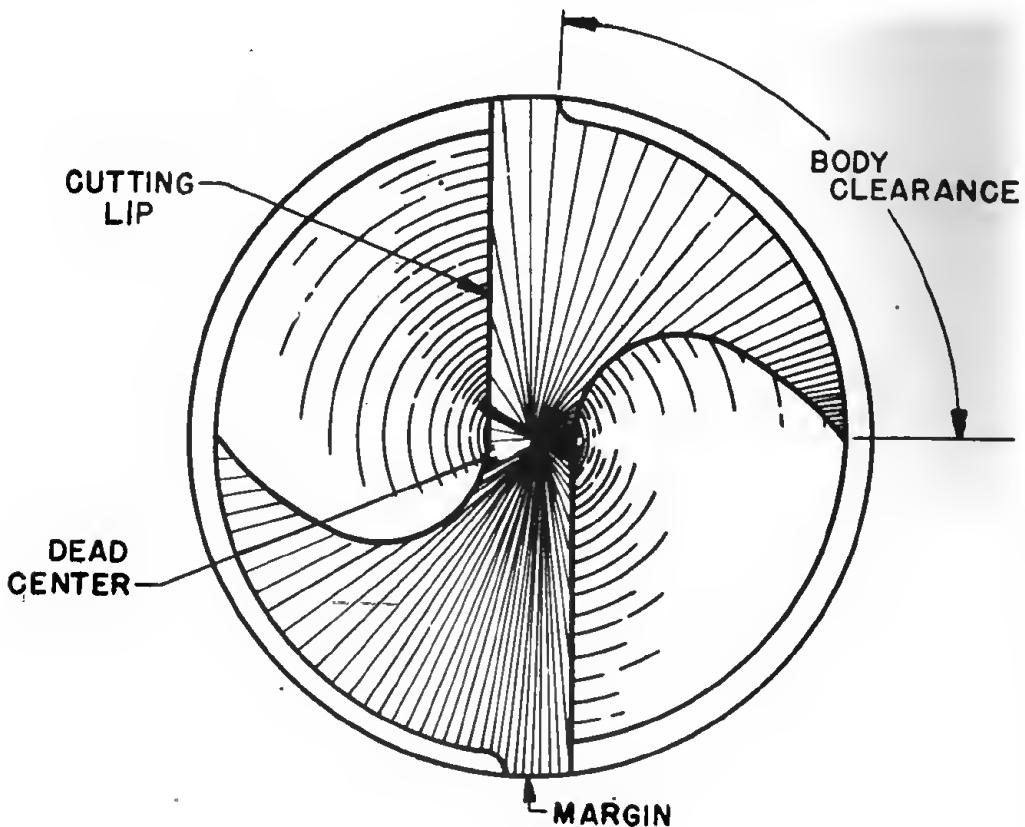


Figure 126. Drill point.

an angle of 59° , and a clearance of 12 to 15° . When grinding a drill point, the drill should be held in the right hand with the point against the grinding wheel at the proper angle. The left hand should hold the shank. (See fig. 127.) With the drill bearing against the grinding wheel, the left hand should push the shank of the drill down and at the same time rotate the drill slightly and push it forward slightly. The drill should be dipped in water often enough to prevent overheating and drawing the temper. To check the length of the cutting lips, a drill-grinding gauge should be used. If no drill-grinding gauge is available, a steel rule may be used. (See fig. 128.) To check the angle of the cutting lips, a drill-grinding gauge must be used. (See fig. 129.) To check the lip clearance, use a piece of paper $8\frac{1}{2}$ inches long and at least 2 inches wide. Place a mark on the left margin $1\frac{1}{4}$ inch from the top and wrap the paper around the drill as shown in figure 130. The edge of the paper should coincide with the clearance angle. It takes practice to learn to grind drills properly, but it is better to spend the time necessary to learn than to attempt to use a drill that is not correctly ground.



Figure 127. How to hold a drill when grinding.

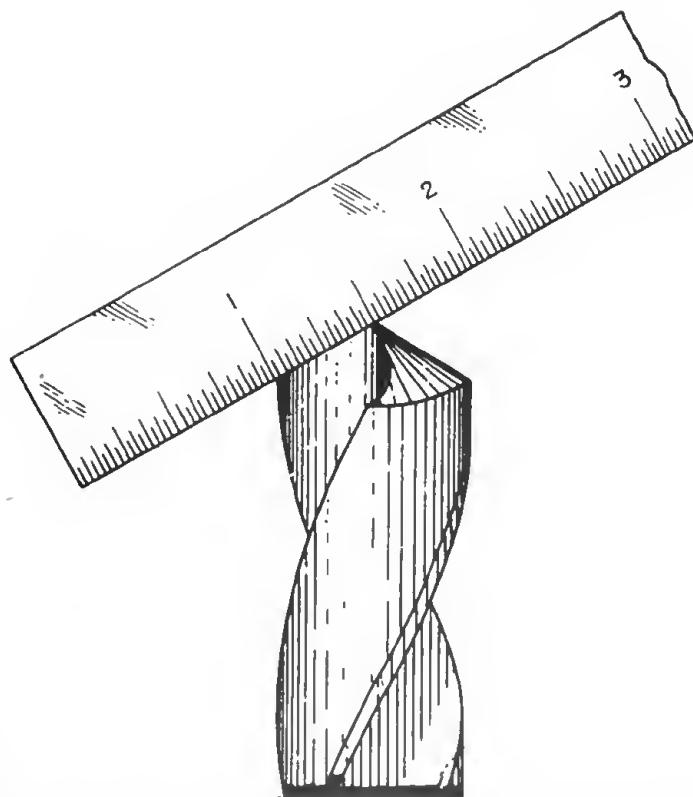
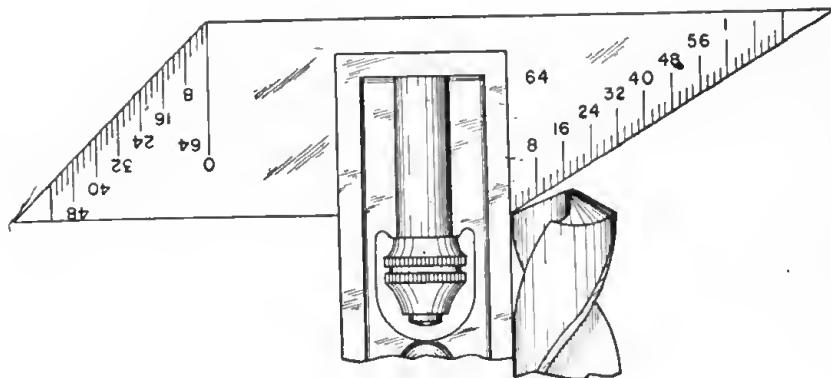
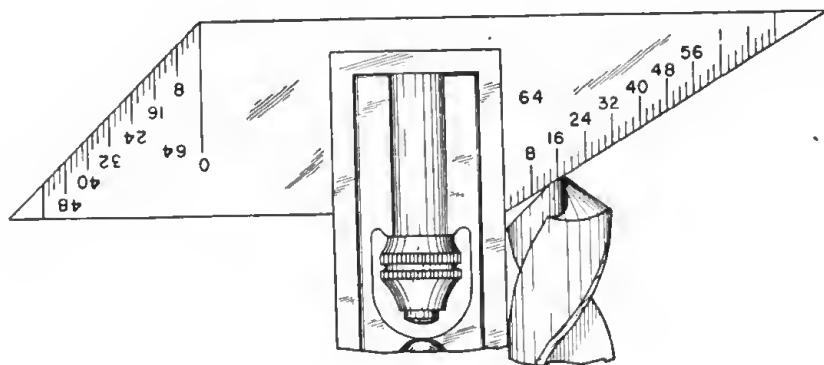


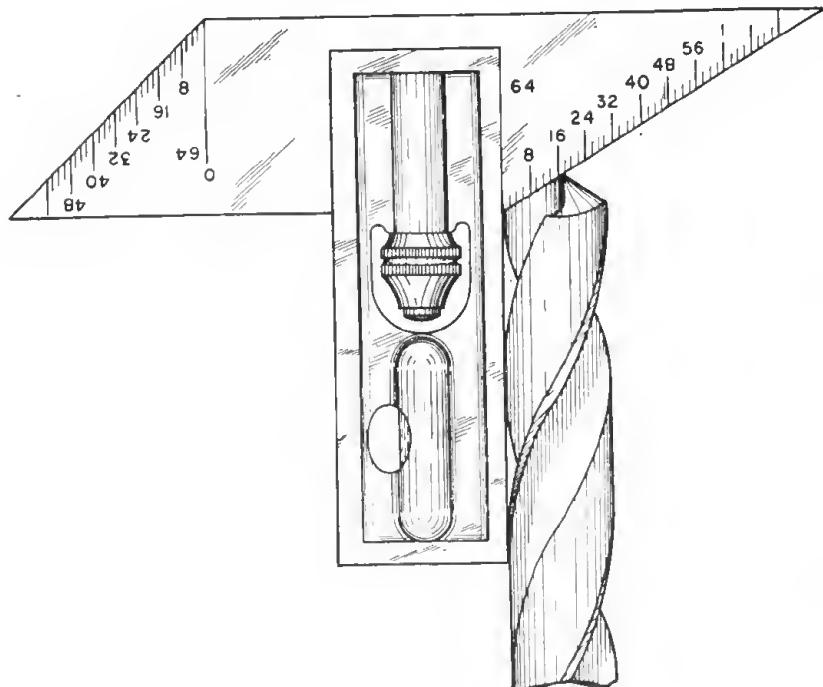
Figure 128. Measuring the length of drill cutting lip with a rule.



ANGLE TOO LARGE



ANGLE TOO SMALL



CORRECT

Figure 129. Checking the angle of drill cutting lips.

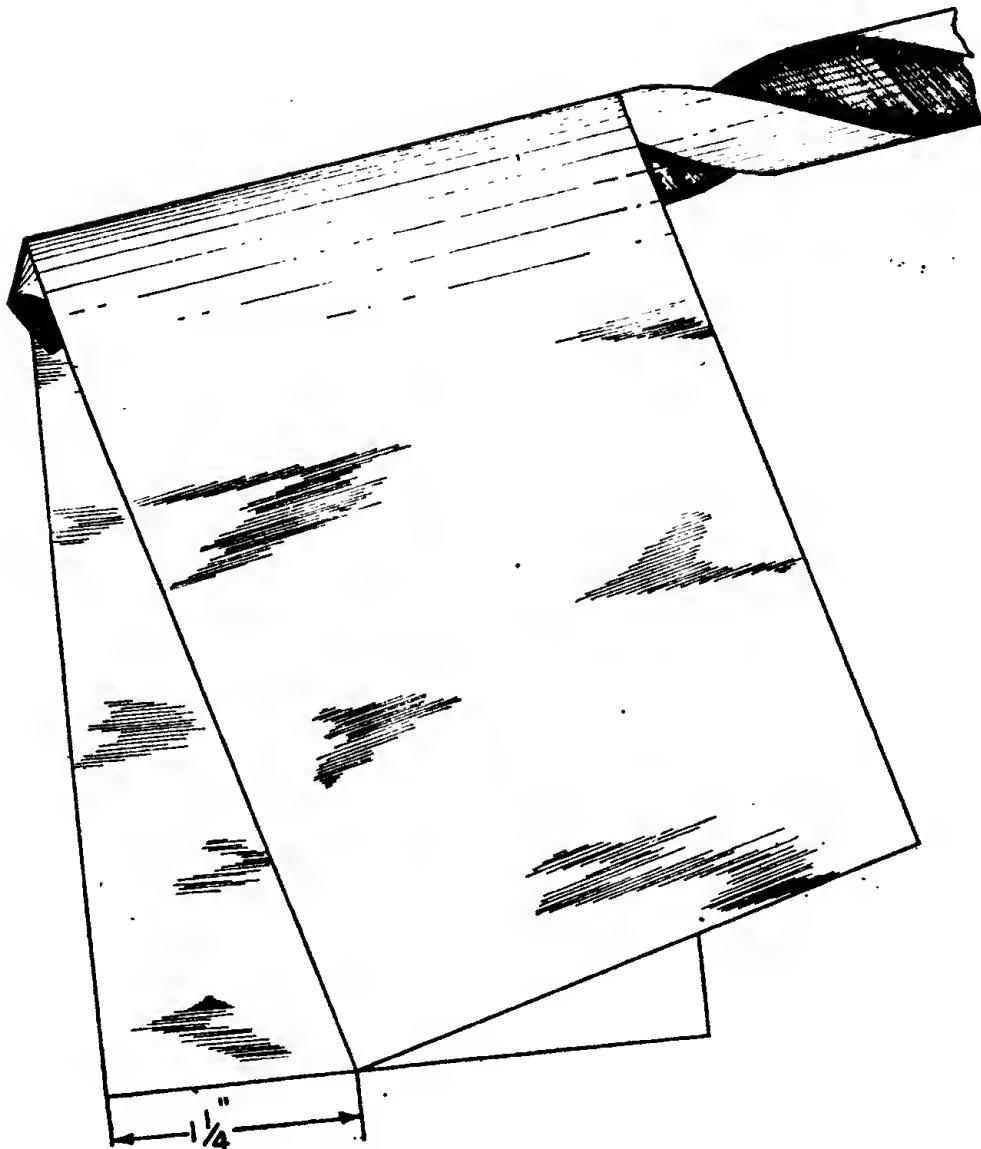


Figure 130. Checking the lip clearance of a drill with a strip of paper.

f. HACKSAWS. (1) A hacksaw (fig. 131) is used to cut metals and other hard materials. It usually has an adjustable frame into which blades of various lengths can be fitted. The position of the blade with respect to the frame may be varied. The blade is installed with the teeth pointing forward; the handle or a wing nut is turned to tighten the blade and hold it in place.

(2) Blades for a hacksaw are made of a hard, tempered steel. They may be all-hard or flexible. The flexible blade has only the teeth tempered while the all-hard blade is all tempered. The teeth may have alternate, raker, or undulated set. (See fig. 132.) There may be 14, 18, 24, or 32 teeth per inch.

(3) The all-hard blade is more rigid and has less tendency to "wander." Therefore, it is used for cutting heavy stock. The flexible blade is less apt

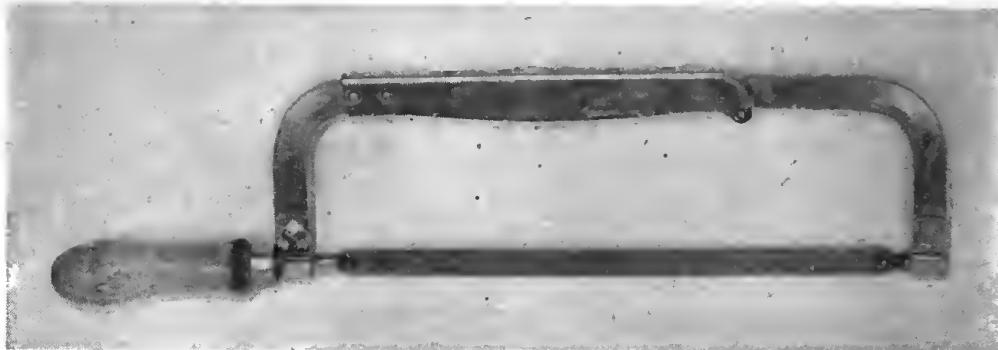


Figure 131. Hacksaw.

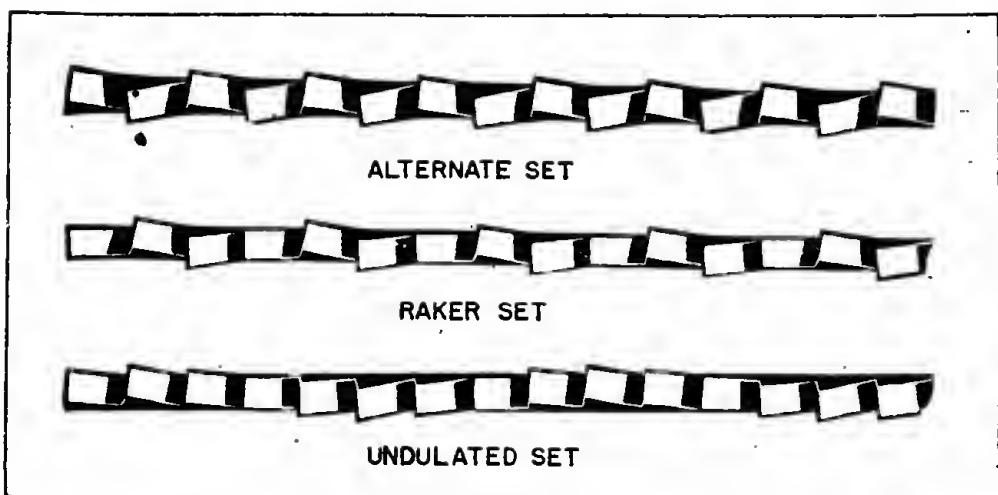


Figure 132. Set of hacksaw blade teeth.

to break and is used for thin stock. A 14-point blade is used for the softest metals and a 32-point blade for the hardest. However, there should always be at least two teeth bearing on the stock, so for thin-walled material a finer blade than ordinary may have to be used. (See fig. 133.)

(4) The use of a hacksaw is similar to the use of a file. The work should be rigid. The stroke should be as long as possible. There should not be over 60 strokes per minute. Pressure should be applied on the forward stroke only.

g. TAPS AND DIES. (1) Taps and dies are used to cut threads on the inside or outside of a hole or cylinder. They are made of hard-tempered steel and ground to an exact size. (See fig. 134.) There are four types of threads that may be cut with standard taps and dies. They are: National coarse, National fine, National extra fine, and National pipe. (See fig. 135.) The pipe threads differ from the others in that they are tapered. Dies may be classified as solid, adjustable-split, and pipe. The three types of taps are taper, plug, and bottoming. (See fig. 136.) For general use, the taper tap is most frequently used.

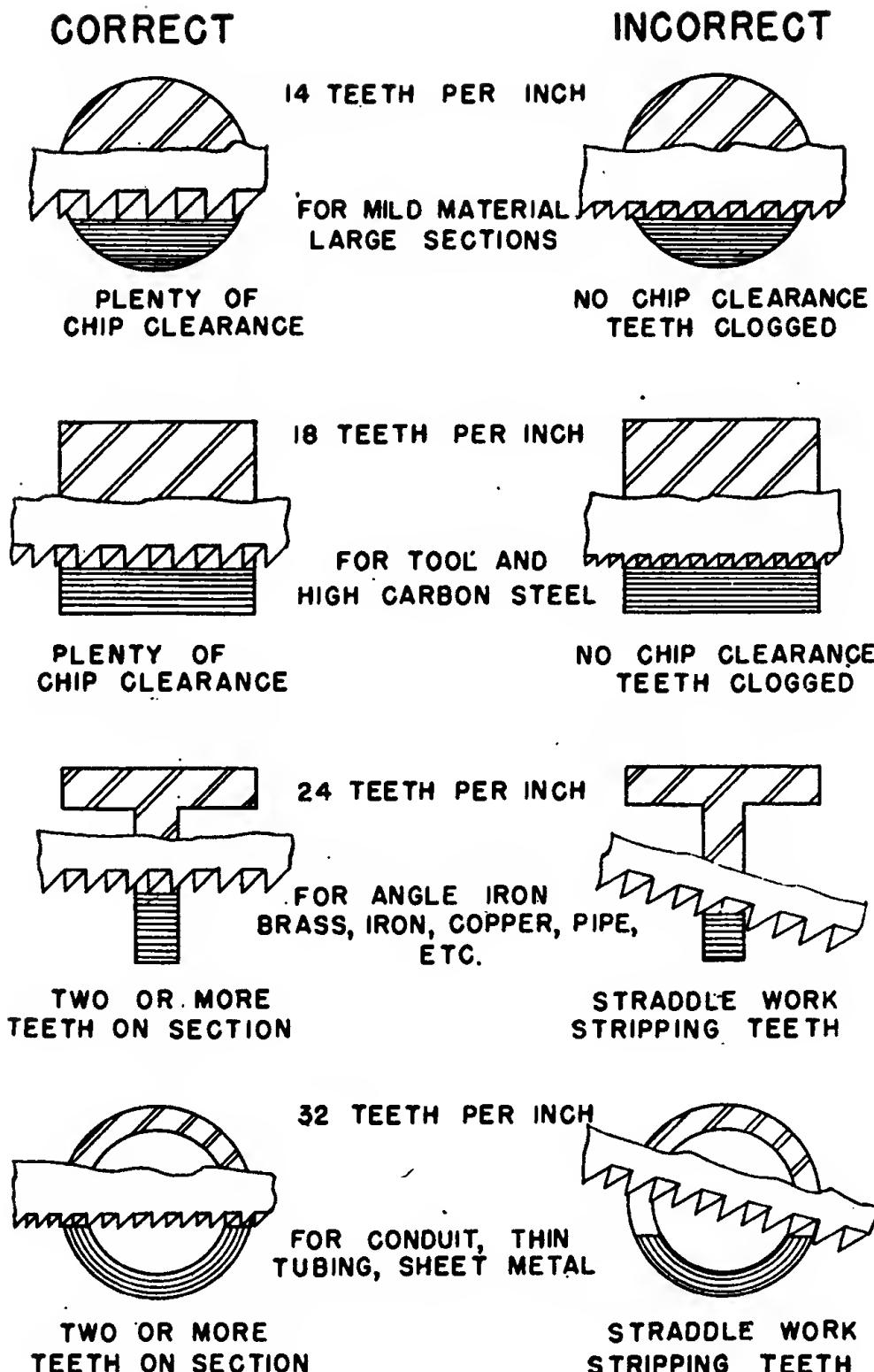


Figure 133. Type of hacksaw blade to use.

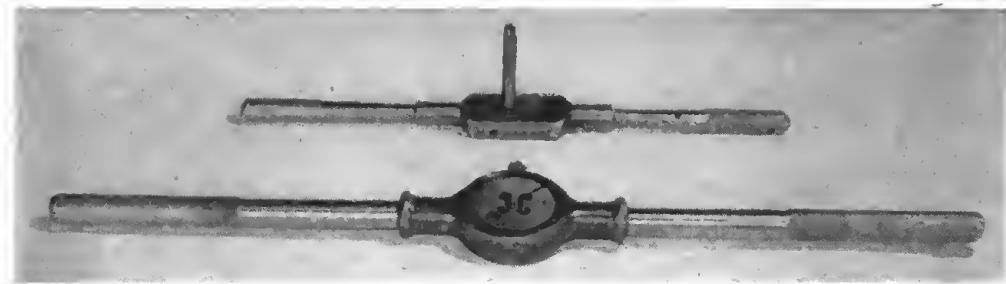


Figure 134. Tap and die in holders.

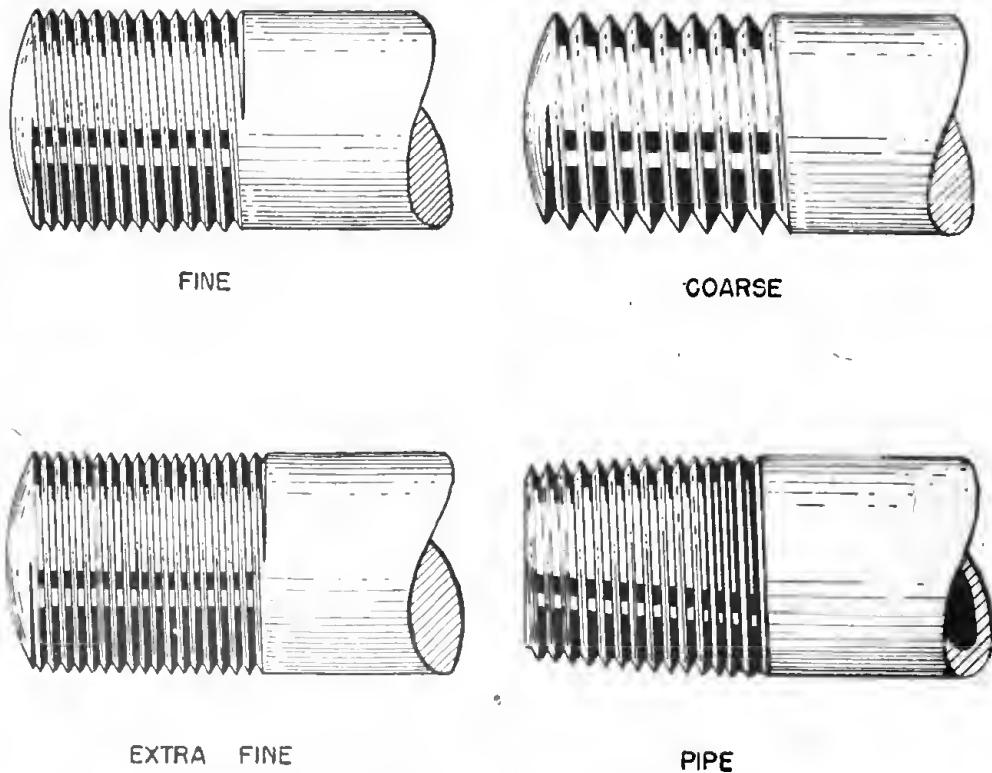
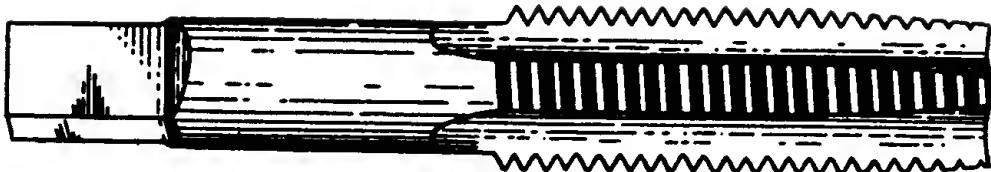
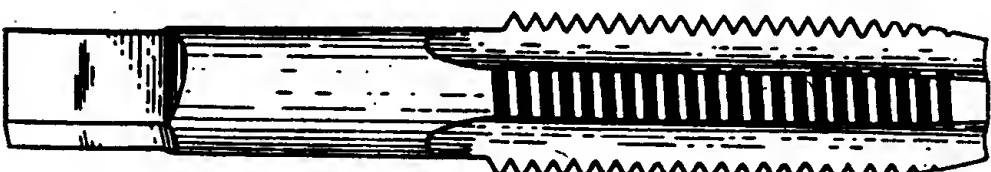


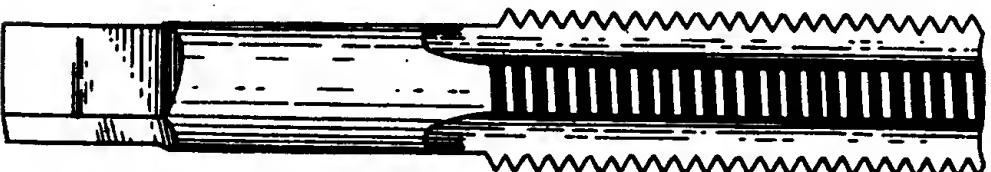
Figure 135. Kinds of threads.



TAPER TAP



PLUG TAP



BOTTOMING TAP

Figure 136. Types of taps.

(2) The hole that is to be tapped must be of the correct size. If it is too small, the tap is likely to be broken. If it is too large, the threads will not be full size and will probably strip. Figure 137 shows the proper size of hole to drill for the various sizes and types of threads. After the hole is drilled, the tap, held by the tap wrench, should be placed in the hole as shown in figure 138. The wrench should be held in the center when starting a tap as it is easier to hold perpendicularly. Pressure should be lightly applied for the first two or three turns, but not after that as the threads of the tap will draw it into the work. The tap should be turned backward about one-third of a turn on every full revolution in order to break off the chip and make the tap cut more easily. Cutting oil should be used. It will not only help prevent overheating and breakage, but will also make cleaner threads. Care should be taken not to run the tap against the bottom of the hole. When the tap can move no farther it will probably break. Once in a while a tap will break off in the hole. If it can be gripped with a pipe wrench it will be a simple matter to remove it. If it cannot be removed with a pipe wrench, it should be started out with a center punch and then removed completely with a tap extractor. (See fig. 139.)

(3) Threading with a die is essentially the same as tapping except that the threads are being cut on the outside instead of the inside. The

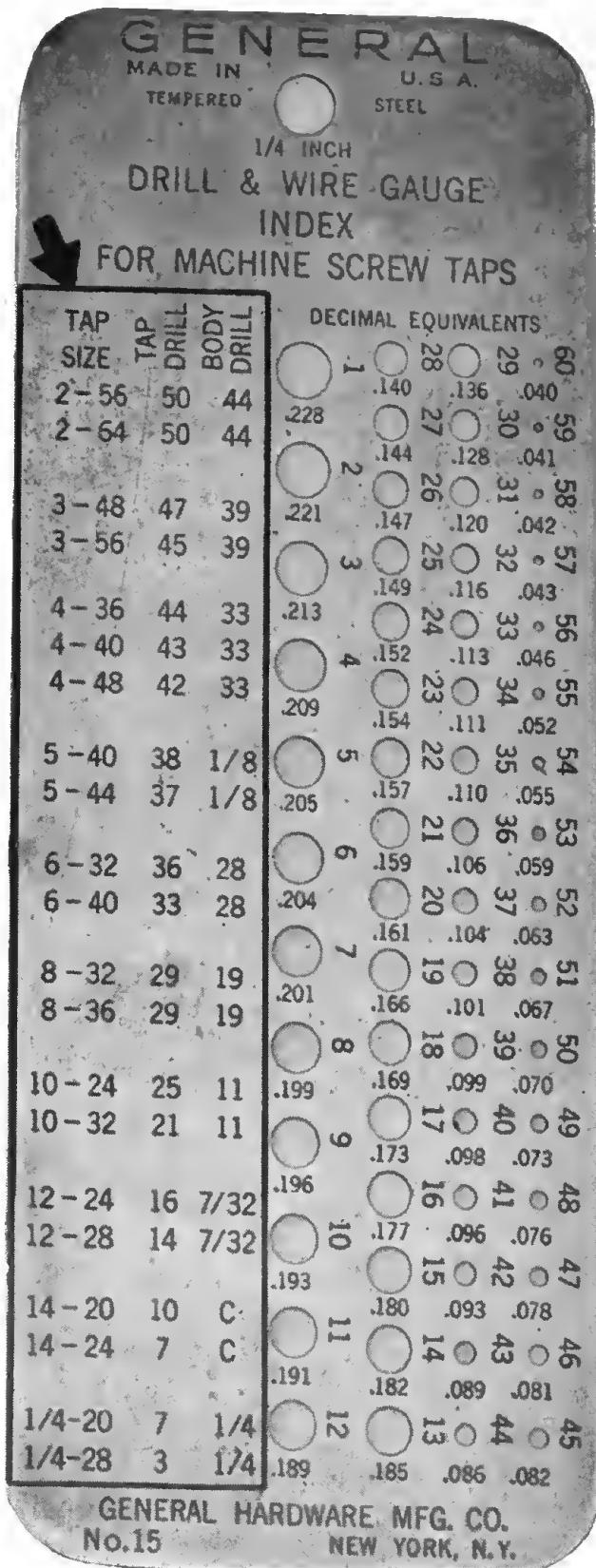


Figure 137. Drill sizes for tapping.



Figure 138. Starting a tap.

method of procedure is the same. Some dies are not adjustable while others are. Turning the adjusting screw of an adjustable die clockwise increases the thread diameter. If the adjusting screw is turned counter-clockwise, the thread diameter will be smaller. (See fig. 140.) The total adjustment possible with most dies will not be over a few thousandths of an inch.

h. SNIPS. (1) Snips are scissors used to cut metal. (See fig. 141.) They may have either straight or curved cutting edges. The curved snips are used to cut small circles and irregular shapes. Snips are to be operated by hand. If they will not cut a piece of metal by hand power alone, it is because they are dull or the metal is too heavy. Do not pound on the handle with a hammer. Get a sharper or heavier pair of snips.

(2) Snips cut with a shearing action. To function properly there should be no play between the blades, and the cutting edges should not be rounded off. Snips are sharpened by dressing with an oil stone. (See fig. 142.)

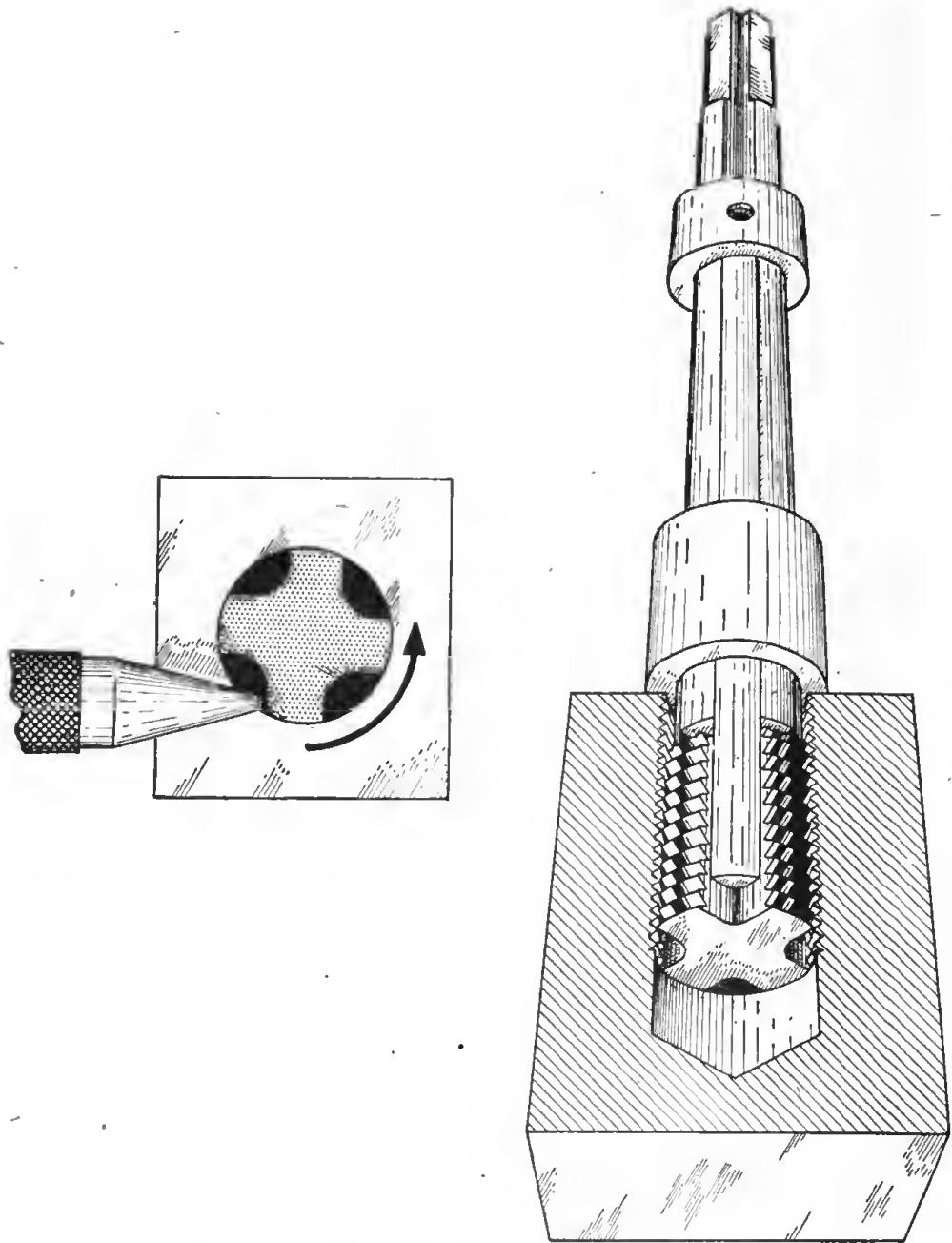


Figure 139. Removing a broken tap with a tap extractor.



Figure 140. Adjusting screw in die.

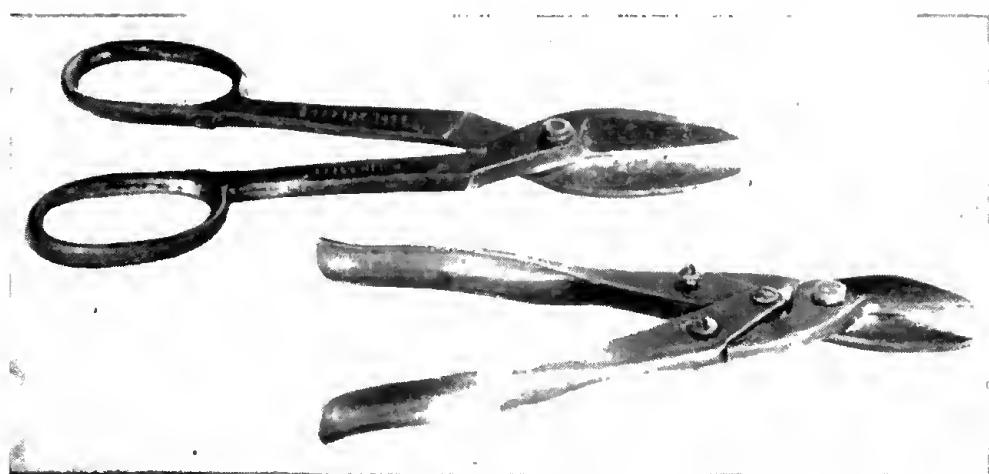


Figure 141. Sheet-metal snips.



Figure 142. Sharpening snips.

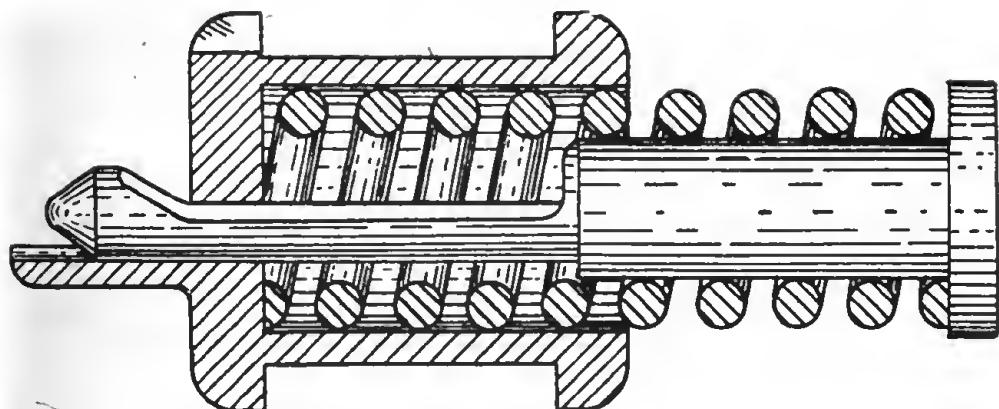
i. CLECO FASTENERS AND PLIERS. (1) A Cleco fastener consists of a small cylinder with a tapered pin in it. (See fig. 143.) The pin is held tightly in the cylinder by a spring. When the fastener is gripped by the Cleco pliers the spring is compressed and the tapered pin forced out of the cylinder, large end first. The pin is then placed through the rivet hole and released. The spring draws the pin back into the cylinder. As the pin moves into the cylinder, it is pushed to one side by a small guide. As the large end of the pin reaches the guide, the two of them (the pin and guide) bear against the sides of the rivet hole and hold the aluminum sheets securely. The size of a Cleco fastener is given as the size of the hole it is made to fit. For example, a $\frac{3}{16}$ -inch Cleco fastener will fit in a $\frac{3}{16}$ -inch hole.

(2) When riveting two sheets of aluminum together, the sheets are aligned and Cleco fasteners placed in every second or third hole. This holds the sheets firmly in place. The holes without fasteners in them are then riveted. The fasteners are then removed and rivets placed in the remaining holes.

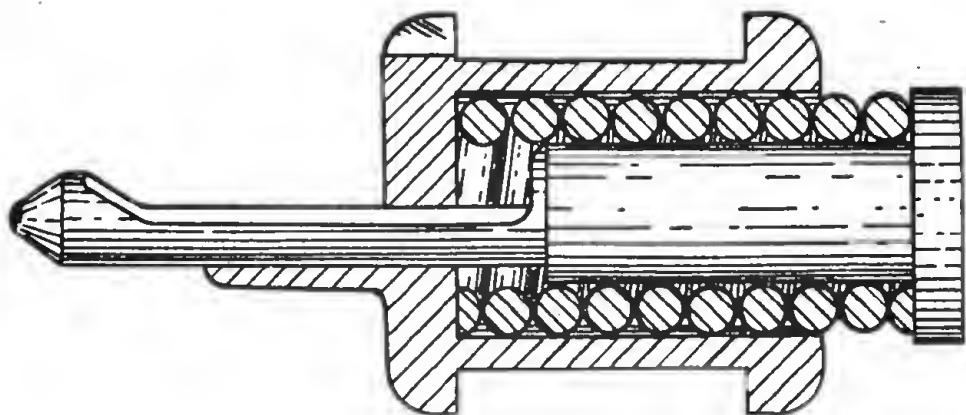
j. BUCKING TOOLS. A bucking tool is a piece of steel with a rod protruding from it. The end of the rod is machined to fit a rivet head. (See fig. 144.) It is held on the head of a rivet while the rivet is "set." It should be held firmly against the rivet head, but does not need to have much pressure applied. The weight of the tool absorbs the shock of setting the rivet.

k. DRIVING TOOL. A driving tool is a rod with a flat face. (See fig. 145.) The face is placed against the rivet and the tool is struck with a hammer.

l. DRAW SET. A draw set is used to force two layers of aluminum together before riveting them. It is similar to a driving tool except that



RELEASED



COMPRESSED

Figure 143. Cleco fastener (sheet holder).



Figure 144. Bucking tool.

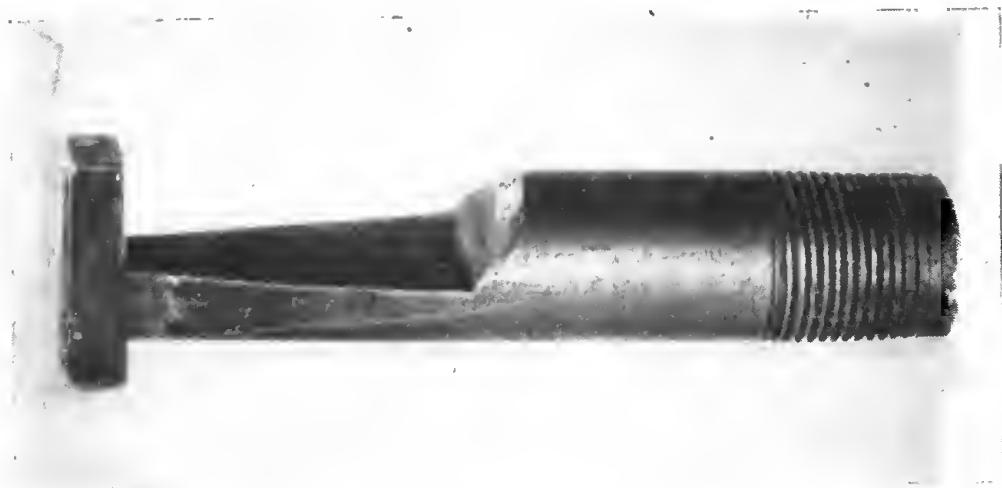


Figure 145. Rivet set.

it has a hole in the end, into which the rivet fits. (See fig. 146.) Therefore, the tool bears against the aluminum sheet, but not against the rivet itself. The draw set is placed over the rivet. The bucking tool is placed against the rivet head. The draw set is then struck with a hammer. This forces the aluminum sheets together. The rivet is then set with the driving tool.

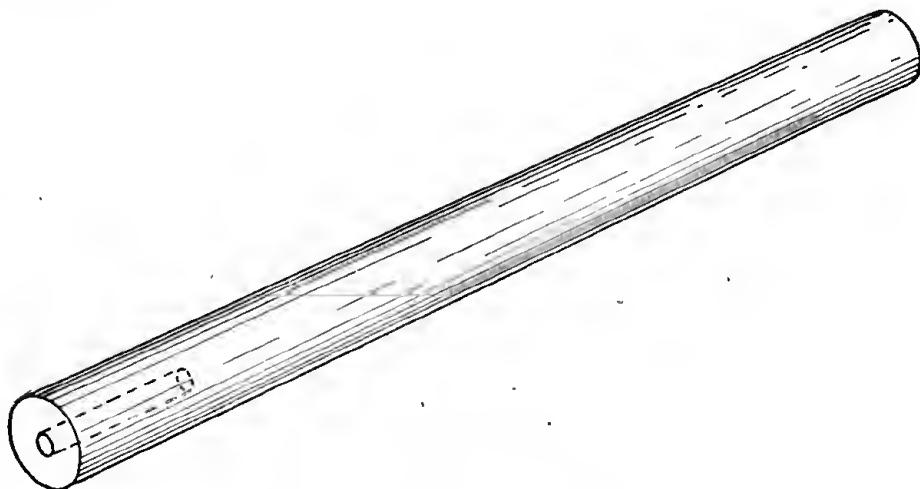


Figure 146. Draw set.

m. DIMPLING TOOLS. These tools are used to prepare sheet metal for countersunk rivets. A set usually consists of a punch die and a draw die. (See fig. 147.) Dimpling may be accomplished by hand or power tools. In using dimpling tools, care should be taken to use the tool with the correct angle.

(1) *Hand dimpling.* Insert the pin on the punch die in the rivet hole. Place the draw die in the bucking bar and hold it against the back of the

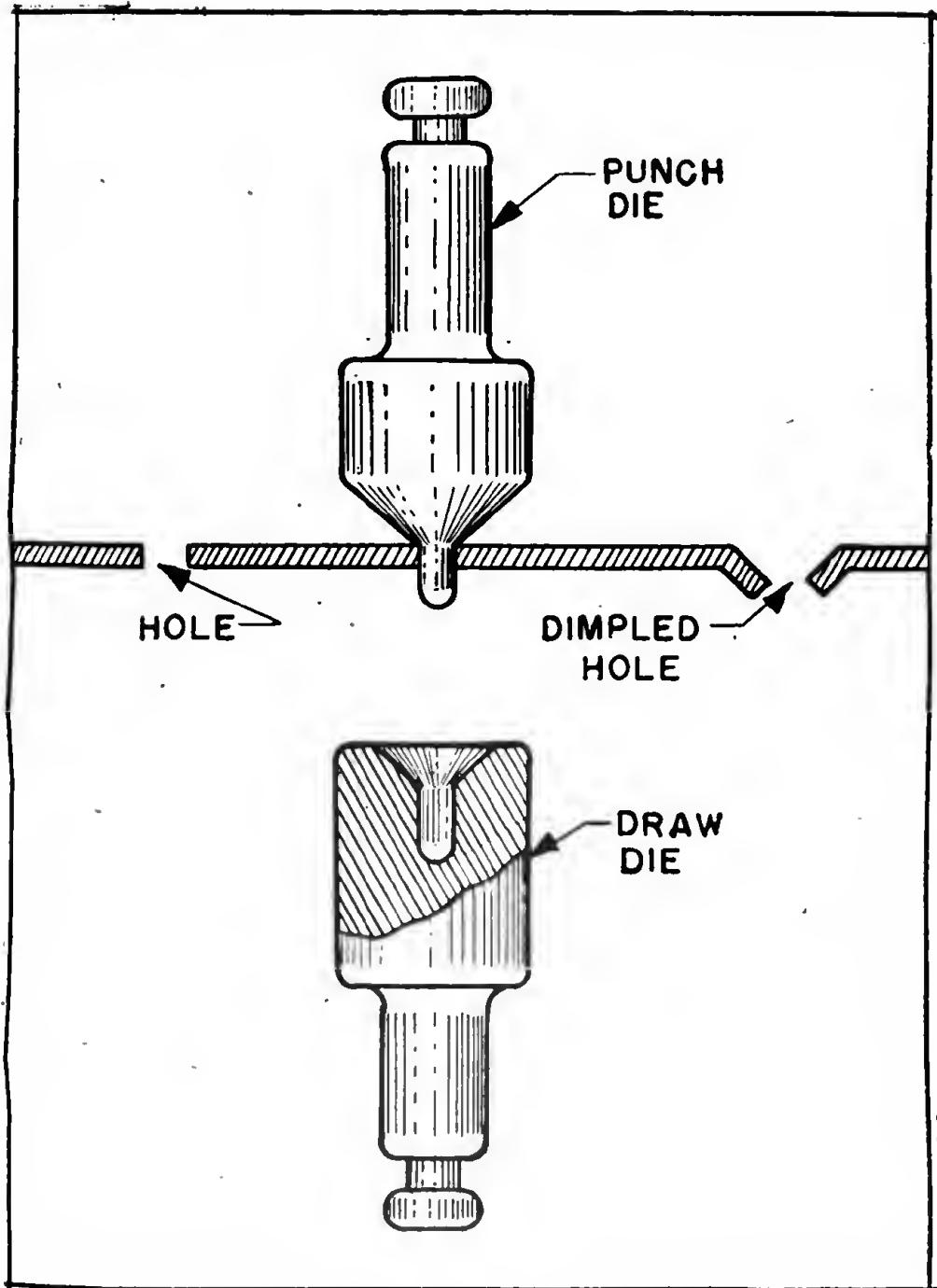


Figure 147. Dimpling tools.

metal. The punch die is then struck with a hammer until a nest of the correct depth and shape has been produced.

(2) *Dimpling with power tools.* Power tools, such as pneumatic hammers and squeezers and dimpling machines, may be used for dimpling. Dies, such as those shown in figure 147, are mounted in the squeezer or dimpling machine as shown in figure 148. Dimpling with pneumatic hammer is accomplished as shown in figure 149.

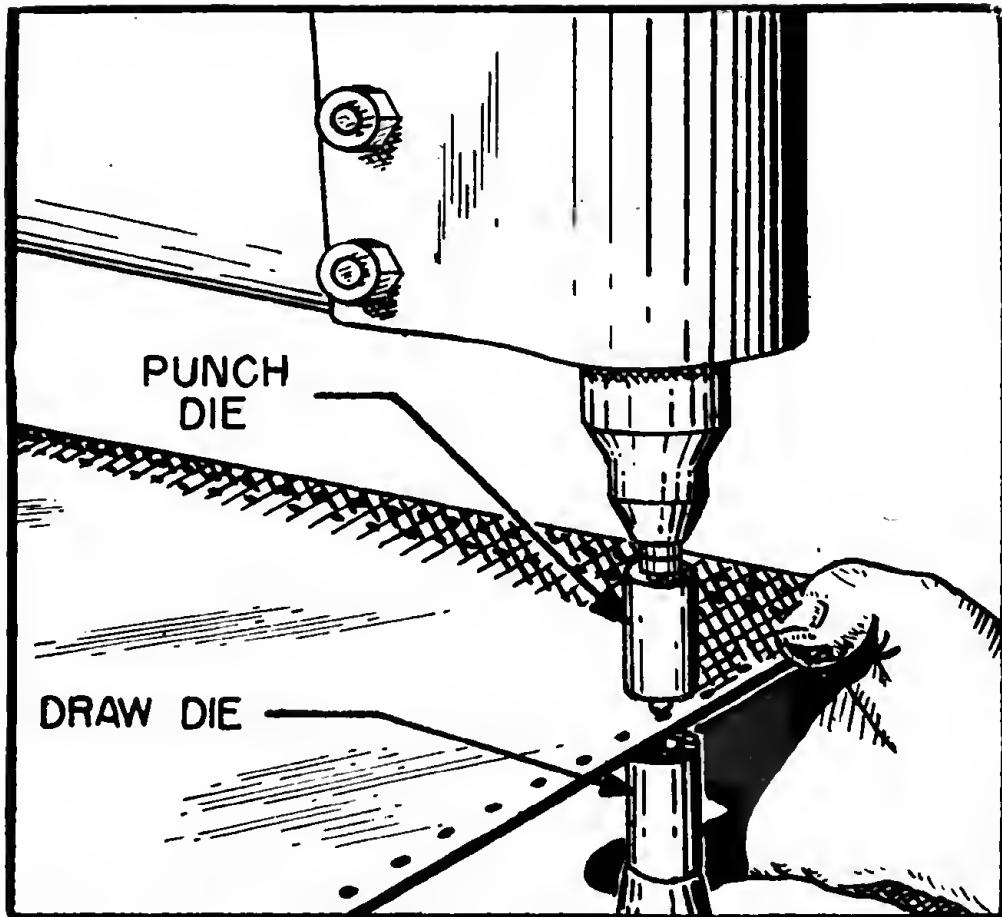


Figure 148. Dimpling sheet metal with a dimpling machine.

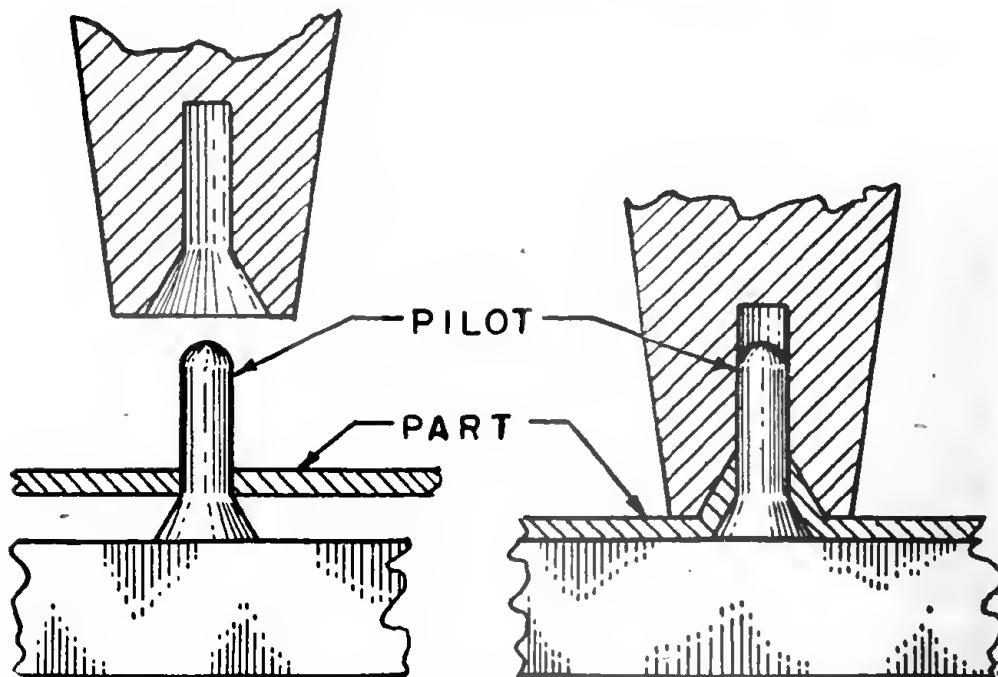


Figure 149. Dimpling sheet metal with a pneumatic hammer.

n. TOOLS FOR REPLACING FASTENERS. Many different types of fasteners are used on aircraft. If these fasteners are broken or worn beyond allowable limits, they must be repaired or replaced. Tools used to replace the most commonly used fasteners are discussed in the following subparagraphs.

(1) *Dzus fasteners.* A set of these tools consists of a beveled punch, a hollow anvil, and a square-ended driving tool. The new grommet is placed in the hole, and the head of the grommet is placed on the anvil. The skirt of the grommet is then spread slightly with the beveled punch. (See fig. 150①.) The fastener is then inserted in the grommet with its end extending into the hollow anvil. The square-ended driving tool is then used against the head of the fastener to spread the grommet and peen it tightly against the sheet. (See fig. 150②.)

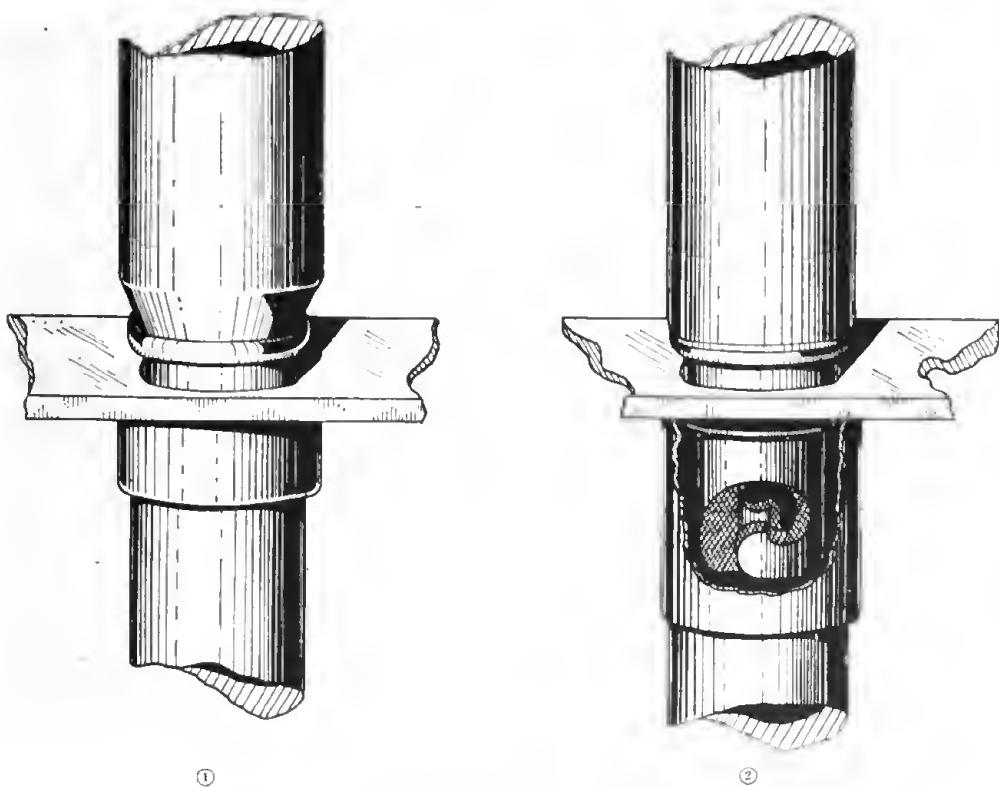


Figure 150. Replacing Dzus fastener grommet.

(2) *Camloc fasteners.* The special tools used to replace these fasteners are a supporting ring, a supporting die, a bucking bar, punches, and Camloc pliers.

(a) To replace a damaged cam collar, insert the new collar in the hole, place the supporting ring over the end of the collar, and place the supporting ring against a bucking bar; then peen the cam-collar skirt with a Camloc punch. (See fig. 151.)

(b) To replace a damaged grommet, insert the new grommet in the



Figure 151. Replacing Camloc cam collar.

hole, place a supporting die or block of metal against the grommet, and flange the skirt with the punch. (See fig. 152.)

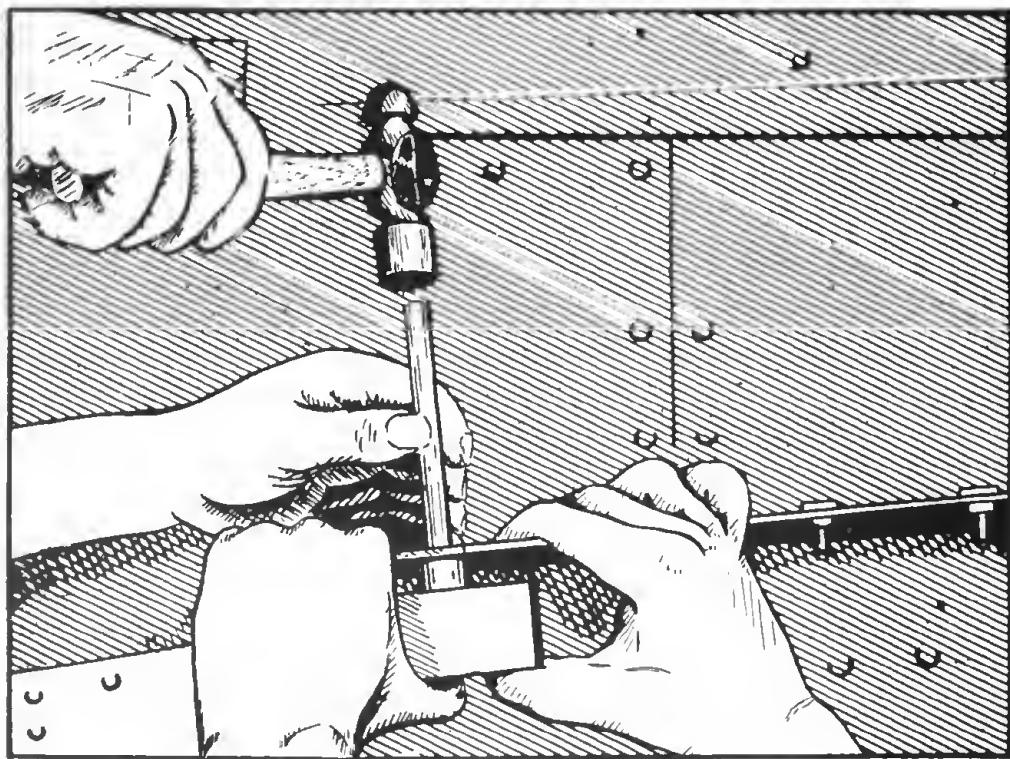


Figure 152. Replacing Camloc grommet.

(c) Camloc pliers are used to insert the stud assembly into the grommet. The spring of the stud assembly is compressed with the pliers and the stud is inserted through the grommet. (See fig. 153.)

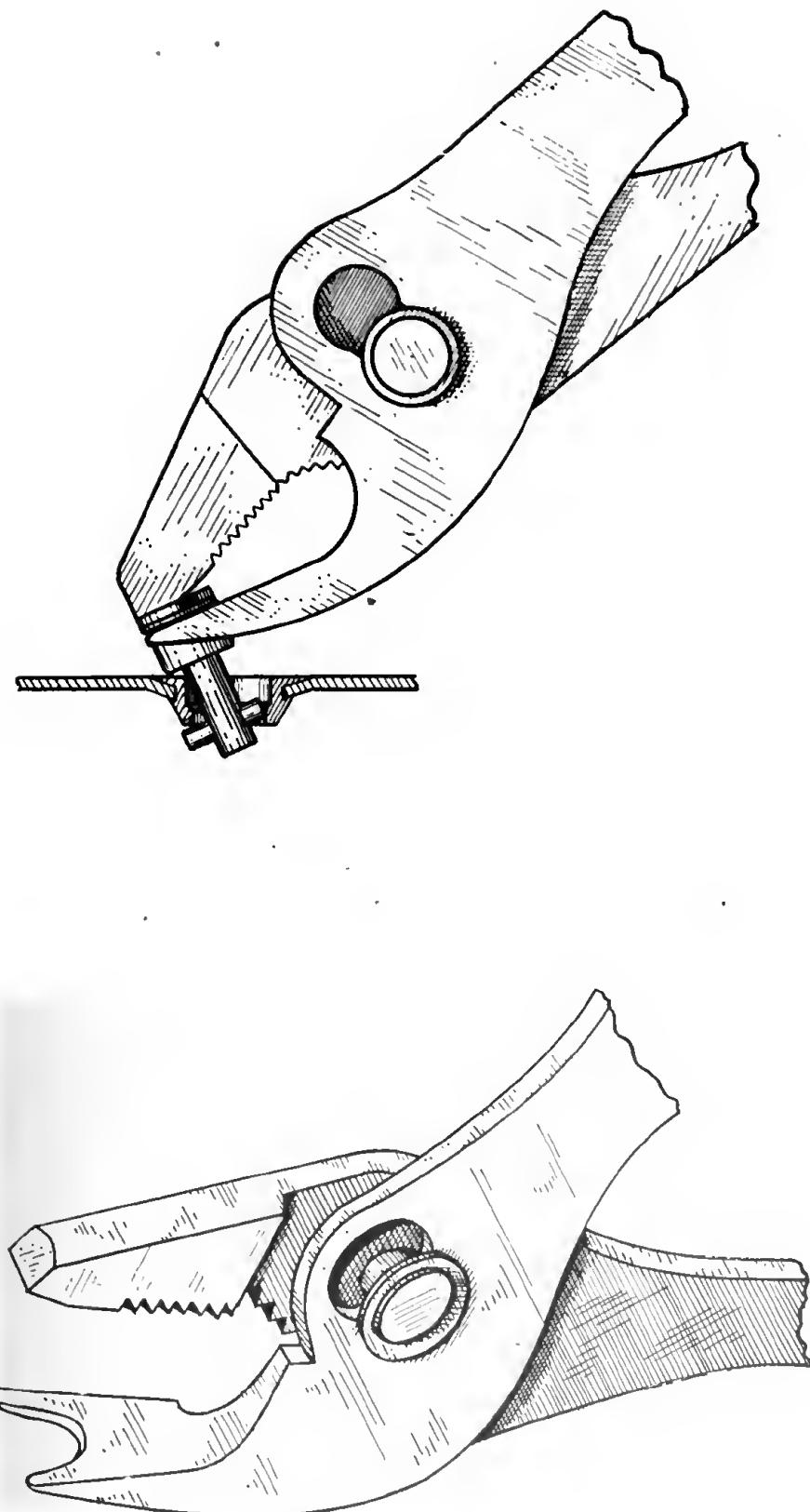


Figure 153. Camloc pliers and their use.

22. Soldering Tools

a. GENERAL. Soldering tools are used to tin materials and unite them with solder. Electrical connections on airplanes are often soldered because soldered connections do not vibrate loose and offer practically no resistance to the flow of the current since the solder itself is a conductor.



Figure 154. Blowtorch.

b. BLOWTORCH. (1) For heating the soldering copper or the material being soldered, a blowtorch is often used. (See fig. 154.) It consists of a heavy brass reservoir and a vaporizing assembly. In the vaporizing assembly there is a small needle valve. In the brass reservoir there is a small air pump.

(2) To start a blowtorch, first fill it with unleaded gasoline. (The lead in aviation gasoline will clog the torch and should not be used.) The filler plug is then screwed in tight and the excess gasoline on the outside wiped off. The air pump is operated a few strokes to put pressure on the gasoline in the reservoir. A small amount of gasoline is placed in the bowl below the vaporizing assembly and ignited. (This gasoline is usually obtained by opening the needle valve a little and allowing the gasoline to drip into the bowl. The needle valve is then closed.) When the gasoline in the bowl is almost all burned, the needle valve is opened.



*Always set a blowtorch on a solid surface
when preparing to light it.*

The gasoline coming from the reservoir passes through the metal heated by the fire and is vaporized. As it passes out from the needle valve it picks up oxygen from the air and burns with a blue flame.

(3) Used correctly, the blowtorch is perfectly safe. Used incorrectly it may explode. Following are some rules governing the use of a torch which should always be strictly adhered to:

- (a) Never light a torch which has gasoline spilled on the reservoir.
- (b) Never light a torch inside an unventilated building or one in which dope, gasoline, or other inflammable materials are being used.
- (c) Never light a torch in the wind.
- (d) Always set a torch on a solid surface when preparing to light it.
- (e) Never move a torch while there is gasoline burning in the bowl below the vaporizing unit.

c. SOLDERING COPPERS. (1) A soldering copper (fig. 155) is used to



Figure 155. Plain and electric soldering copper.

convey the heat to the material being soldered. It is no more than a piece of copper tapered to a point, and fastened to a handle so that it may be held. The grip of the handle is usually made of wood. Electric soldering coppers have an electric heating element inside the copper. Plain soldering coppers are solid copper and must be heated by a blowtorch or other source of heat.

(2) Before a soldering copper may be used, it must be tinned, that is, its surface must be coated with solder. If necessary, the copper is first filed to the proper shape. (See fig. 156.) It is then heated. While hot, it is filed slightly and dipped into a flux; then the solder is applied to it. At least the entire point of the copper should be tinned. If it does not all tin the first time, the copper should be reheated and reapplied to the flux and solder.

d. FLUX. Flux is used when soldering to retard the formation of oxides, and remove them from the surface of the metal, so that the solder

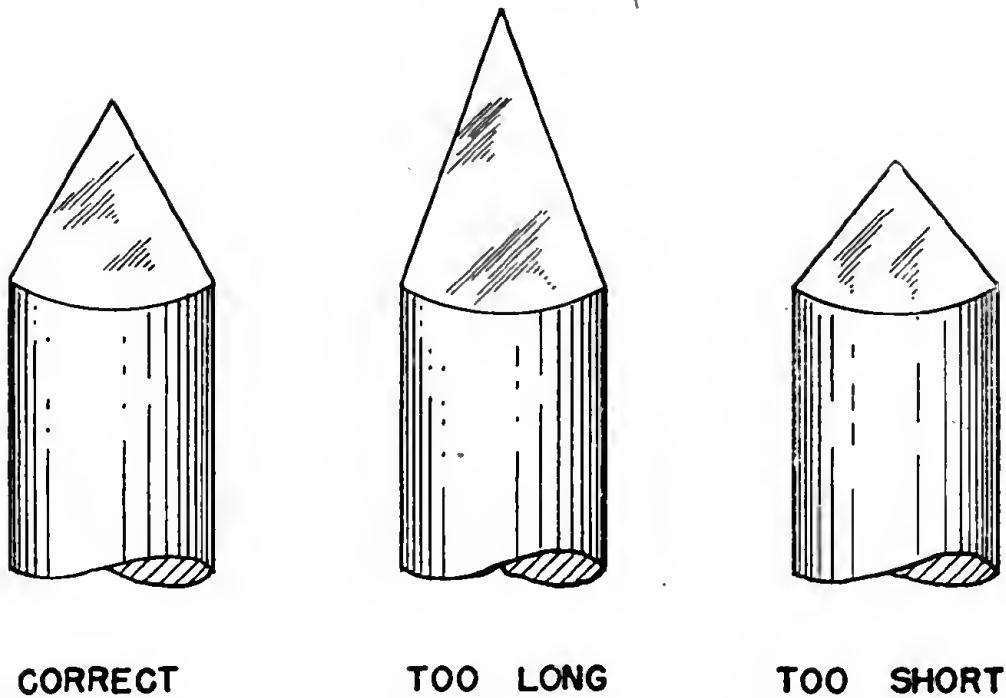
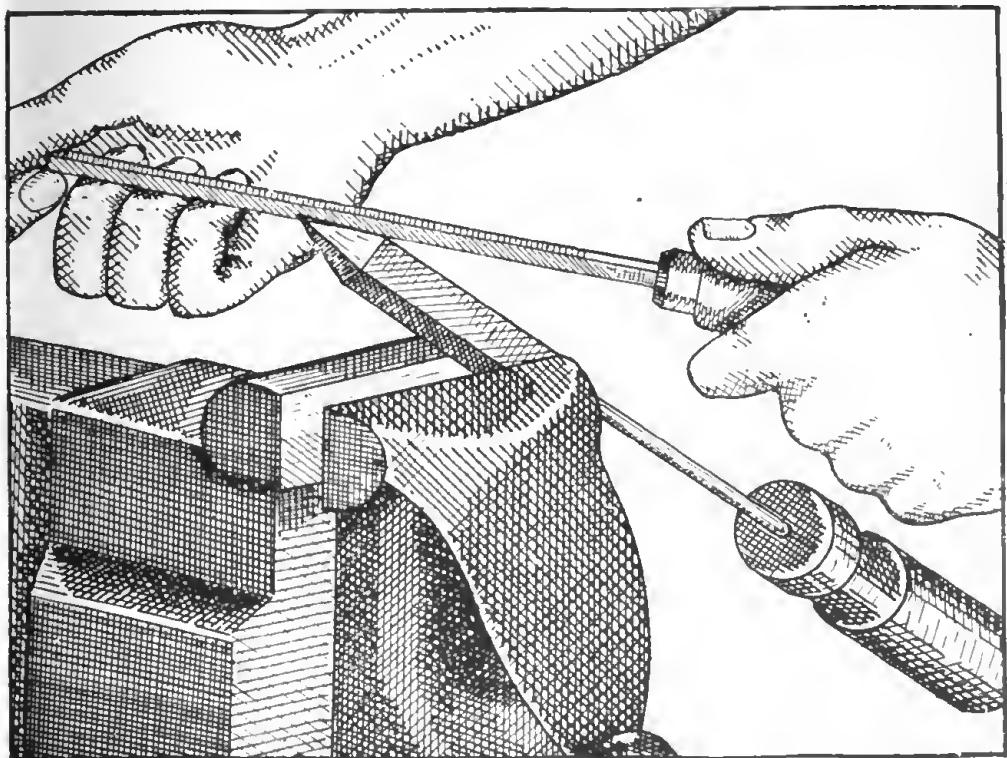


Figure 156. Shape of soldering copper.



Filing a soldering copper to correct shape.

will stick. Practically all metals will oxidize when heated. This oxide on the surface of the metal will prevent the solder from sticking to the metal. The two most common fluxes are acid and rosin. The acid flux is not really acid, but is a solution zinc to react with hydrochloric (muriatic) acid. Acid flux is more efficient than rosin and works better on dirty materials. It should not be used on electrical work because it causes corrosion. Rosin flux is used for electrical work.

e. POINTERS ON SOLDERING. (1) The most common cause of failure when soldering is a cold copper. Only experience will tell when the copper is of the correct temperature, but if the solder does not flow readily, it is probably because the copper is not hot enough. The solder should flow out thinly like water.

(2) Another common cause of unsatisfactory soldering is dirty material. The surface to be soldered must be thoroughly cleaned by brushing, scraping, or filing before attempting to solder it. The material should then be tinned. Plenty of heat, and brushing with a wire brush, or filing, and very little solder will usually give good results.

(3) Soldering light material to heavy material is often difficult for the beginner. The solder will flow well on the light material and look satisfactory, but the heavy material has not been heated sufficiently and the solder will not hold. The size of the material must be taken into consideration when soldering. Since more heat must be applied for heavy work, a larger soldering copper should be used. Holding a large soldering copper on the heavy material until the solder flows freely and then applying the light material will make a satisfactory connection when different weights of material are being soldered. Materials held in a vise while being soldered should be insulated from the vise jaws by two small blocks of wood. Otherwise the heat will flow rapidly from the material and make it more difficult to solder.

(4) If it is necessary to solder a gasoline container, the following procedure must be strictly adhered to, regardless of how the container is cleaned before soldering:

- (a) Work in the open, at least 50 feet from a building.
- (b) Do not use an electric soldering copper.
- (c) Place the blowtorch at least 50 feet from the work.
- (d) Heat the copper on the blowtorch and carry the copper to the work.
- (e) Take the copper back to the torch for reheating.

23. Fabric-working Tools

a. GENERAL. The fabric of wood-and-fabric airplanes and of the control surfaces of bombers and fighters is sometimes damaged by bullets and shell fragments. The airplane mechanic will make minor repairs on damaged fabric. The work must be done carefully. If a patch comes loose during flight, it may cause the airplane to crash.

b. SHEARS. To cut the fabric used for repair, pinking shears are used.

(See fig. 157.) The edge of cloth cut with pinking shears does not fray. If they become dull they may be sharpened by carefully dressing the flat

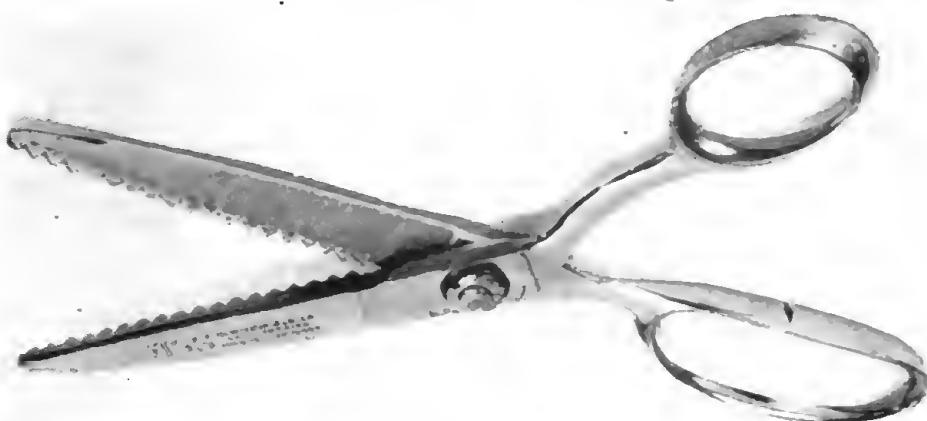


Figure 157. Pinking shears.

surface of each blade on an oil stone. The surface of the notches should not be dressed. (See fig. 158.)

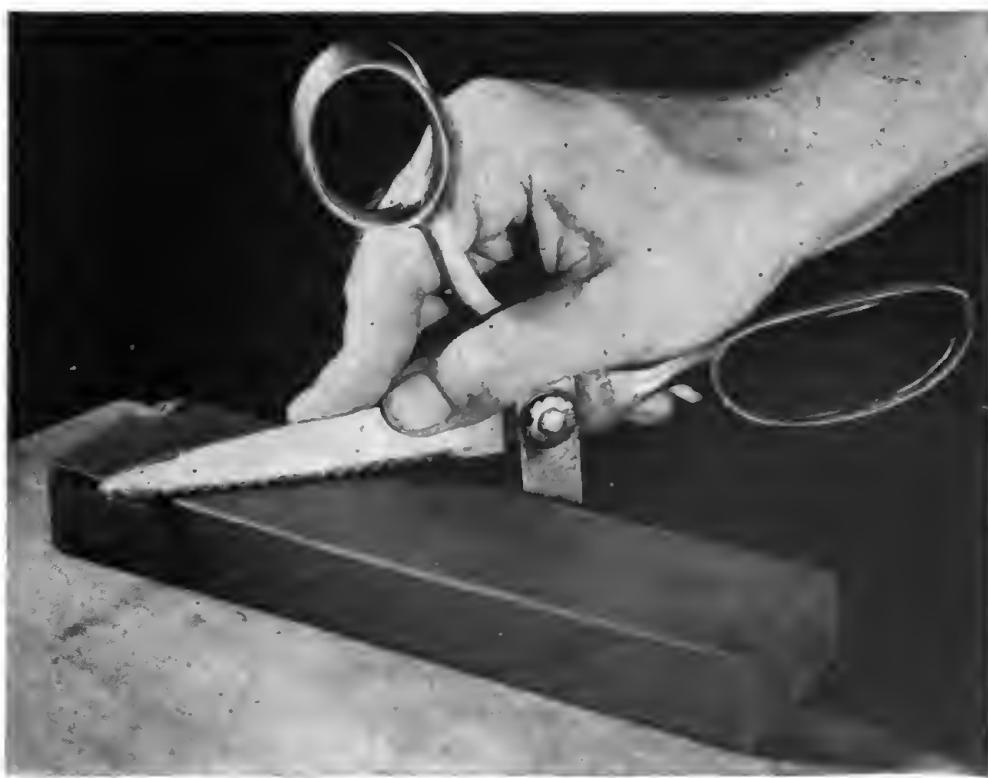


Figure 158. Sharpening pinking shears.

c. NEEDLES. Straight and curved needles are used when sewing the original fabric on an airplane. When patching, only the curved needle is used. The baseball stitch is used to sew the patches in place.

d. PUTTY KNIFE. Before sewing a patch on fabric which has dope

on it, the dope must be removed. This is done by applying a mixture of thinner and dope and allowing it to soften the finish. The surface is then scraped with a putty knife, removing the loosened dope. Care must be exercised to prevent tearing the fabric with the putty knife. A putty knife is shown in figure 159.



Figure 159. Putty knife.

c. BRUSH. The use of a brush is familiar to everyone. However, the life of many brushes is materially shortened by allowing dope and paint to dry on them. A brush that is used frequently may be kept in a sealed can of solvent when not in use. It should not be allowed to rest on its bristles but should be supported by the handle so that the bristles are just off the bottom of the container. (See fig. 160.) If a brush is used only infrequently, it should be thoroughly cleaned after each use. This may be accomplished by first cleaning with the proper solvent and then scrubbing the brush with soap and water. After scrubbing, the brush should be rinsed with clear water. If any odor of the solvent can be detected after rinsing, it should be rewashed.

24. Tubing Tools

a. GENERAL. Most of the fluids in an airplane, such as gasoline, oil, hydraulic fluid, etc., are transmitted through seamless aluminum, copper, or steel tubing. Fabrication of this tubing requires special tools. The mechanic should be familiar with these tools and their use in order to be able to make repairs.

b. TUBE-CUTTING TOOL. (1) The tube-cutting tool is similar in construction and operation to a pipe cutter. It has a cutting wheel and two rollers. They are located in such a position that they will hold a piece of tubing between them. The rollers are adjustable. They may be moved to or from the cutting wheel by a hand-adjusted screw. (See fig. 161.)

(2) The tube cutter is used to cut tubing to the proper length. The tubing is placed in the cutter and the screw is tightened until the cutter and rollers just touch the tube. The cutter must touch the exact line where the tubing is to be cut. The hand screw is tightened a little and the cutter rotated around the tube. The screw is tightened a little more and the cutter is rotated again. This is continued until the tubing is cut off. The screw should not be tightened very much at a time. If it is, the rollers will be sprung out of place and the cutter will be worthless.

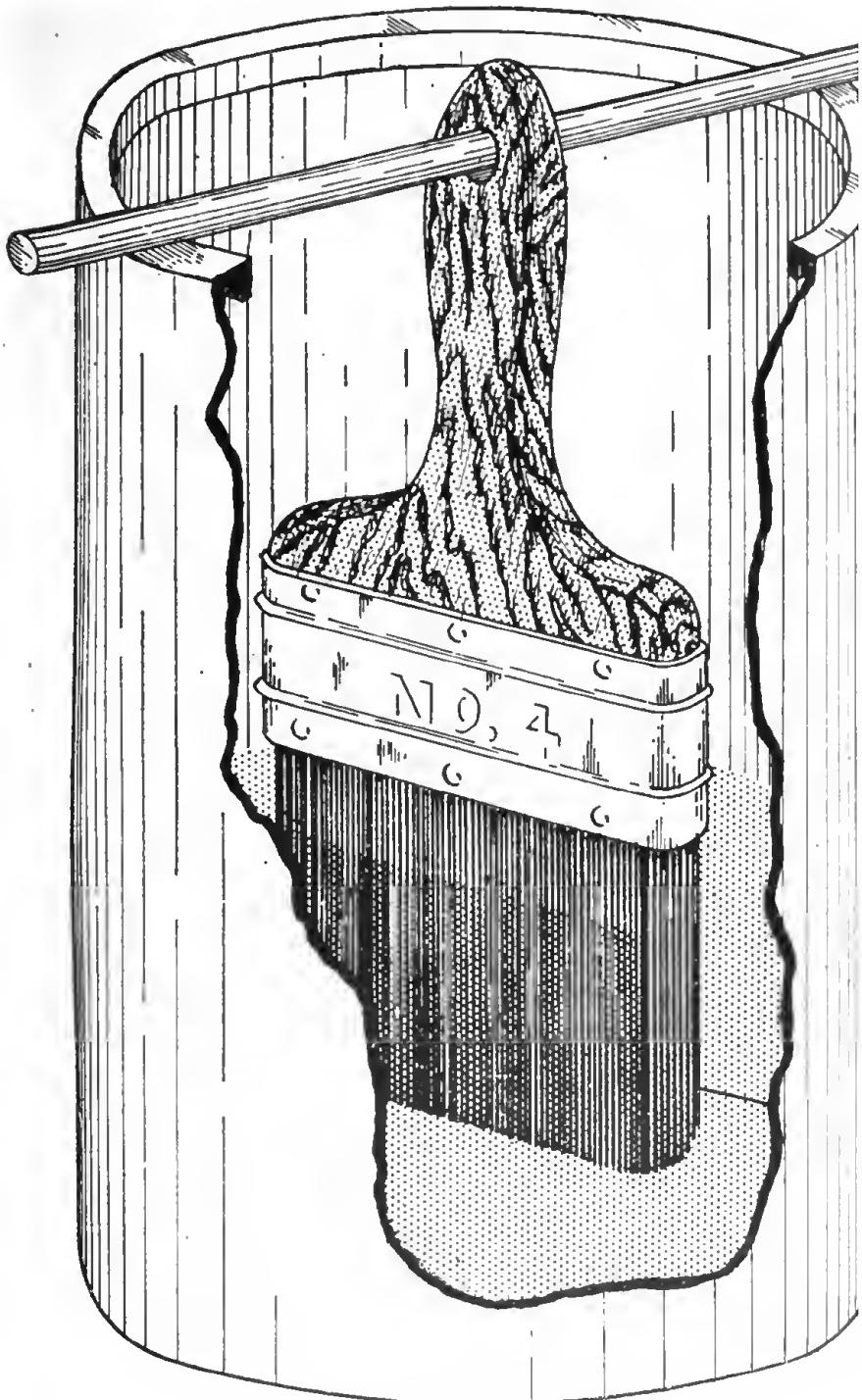


Figure 160. Container for brush.

(3) After being cut with a tube cutter, there will be a burr inside of the tubing. This may be removed by the reamer on the tube cutter. After the burr is removed, the inside of the tube be wiped or blown out to remove the small bits of loose metal.

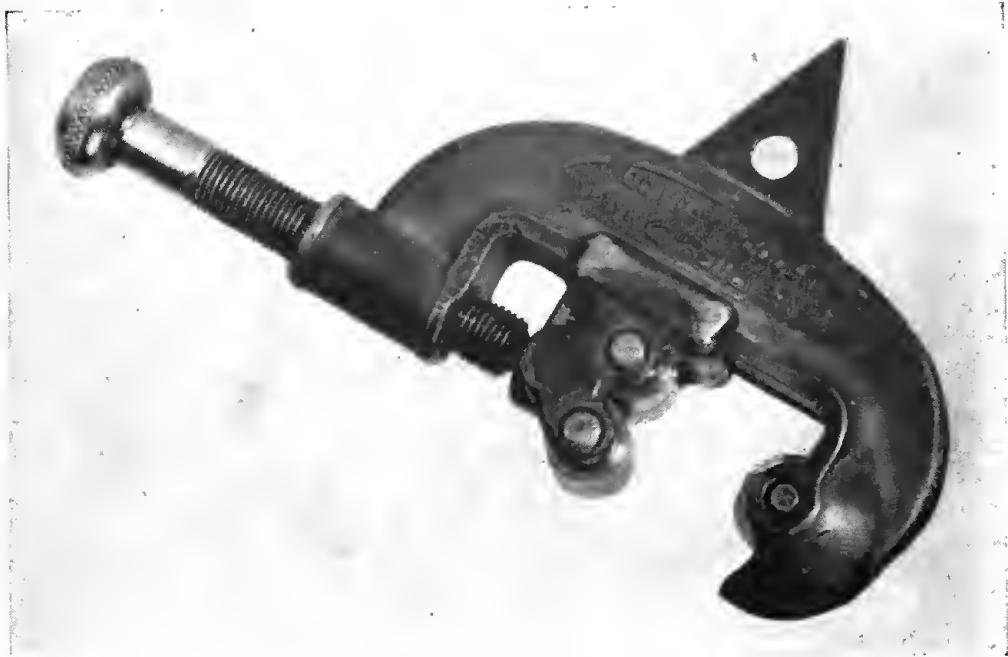
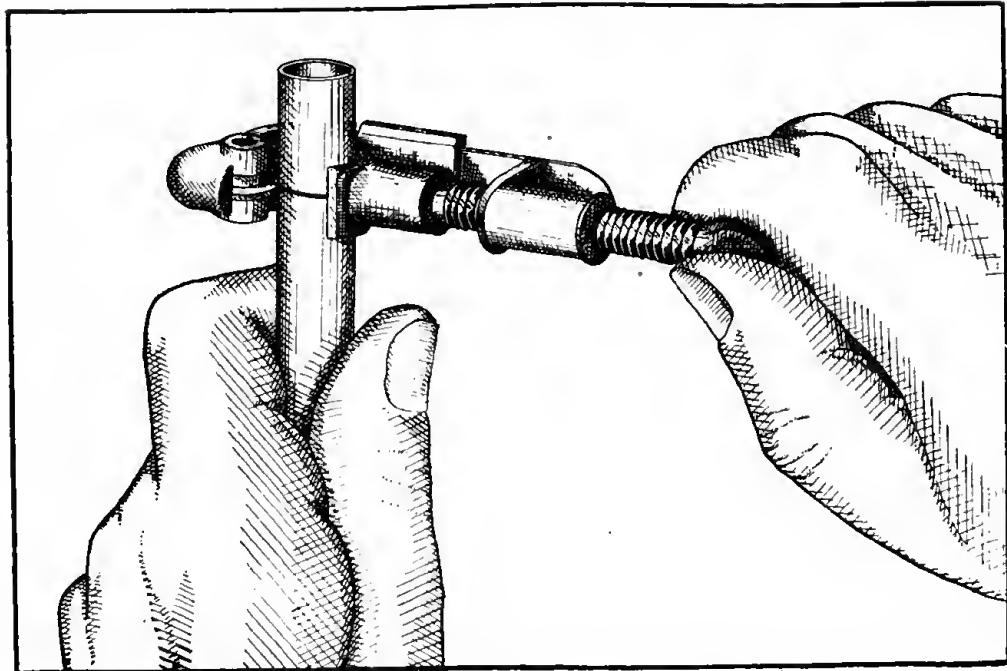


Figure 161. Tube-cutting tool.



Cutting tube with tube-cutting tool.

c. TUBE-FLARING TOOL. (1) Flared tube connections are used to join tubing to fittings, bulkhead connections, and units. There are two types of tube-flaring tools: combination and individual. (See fig. 162.) The combination flaring tool will fit tubing ranging in size from $\frac{1}{8}$ - to $\frac{1}{2}$ -OD. The individual flaring tool will fit only the one size for which it was made.

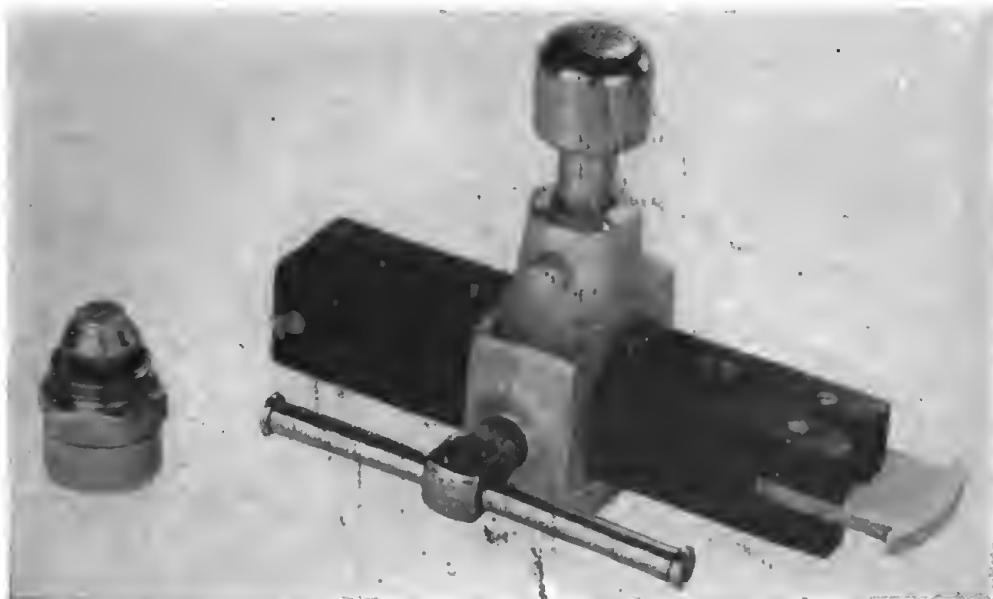


Figure 162. Tube-flaring tools.

(2) To flare a tube with the combination flaring tool, the tubing is placed in the proper recess in the tool so that it extends $\frac{1}{32}$ to $\frac{1}{16}$ inch (depending on the diameter of the tubing) above the surface of the tool. The tool is then tightened. The plunger (also called the flaring pin) on the top of the tool is then pushed against the tubing and the assembly is checked to make sure everything is in the proper position. (See fig. 163.) A hammer is used to strike the plunger 10 or 12 medium-heavy blows. The plunger is rotated slightly after each hammer blow to insure a uniform flare. The flare sleeve and nut must be placed on the tubing before the flare is made. To make a flared tube connection with an individual flaring tool, the sleeve is placed in the nut, the nut screwed on the tool, and the tubing inserted through the sleeve. (See fig. 164.) The tubing is held and the head of the flaring tool struck with a hammer. The plunger is rotated after each blow to produce a uniform flare.

(3) The proper diameter for a flare depends upon the diameter of the tubing. If available, a go, no-go gauge should be used on each flare to make sure it is of the proper size. If a gauge is not available, the flare may be checked for size with the sleeve and nut. The outside diameter of the flare should be greater than the outside diameter of the sleeve, and less than the inside diameter of the threads of the nut. The diameter of a flare produced with a combination tool depends upon the height

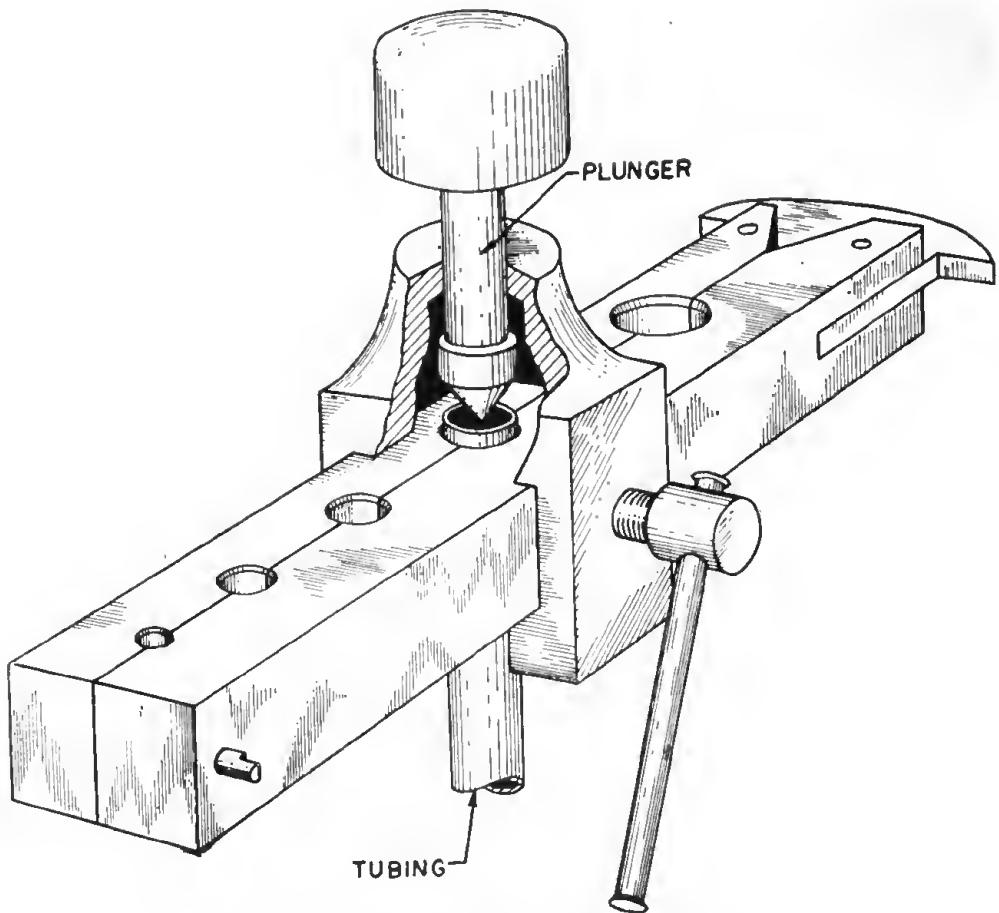


Figure 163. Combination flaring tool in use.

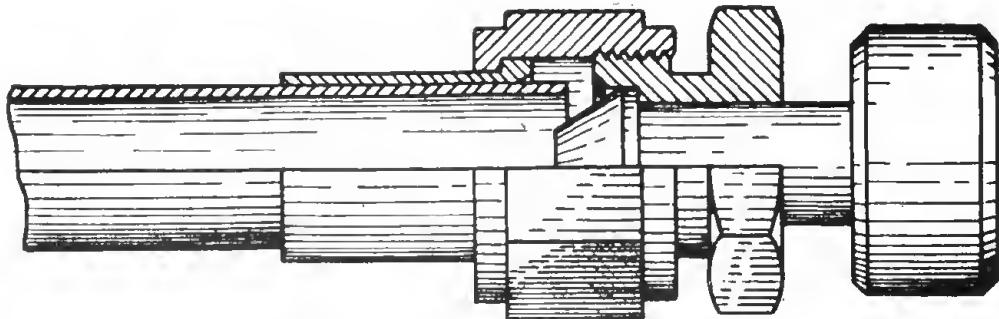


Figure 164. Position of tubing in individual flaring tool.

the tube protrudes above the top of the flaring tool. The diameter of a flare produced with an individual flaring tool depends on the amount the plunger is struck with the hammer.

d. TUBE-BENDING TOOL. (1) This tool is used to bend the tubing in order to make it fit in the position required. It has two handles. One of the handles is fastened to a circular piece of metal around which the tubing is bent. The radius of this circular piece of metal is the minimum radius around which the tubing may be safely bent. The other handle has

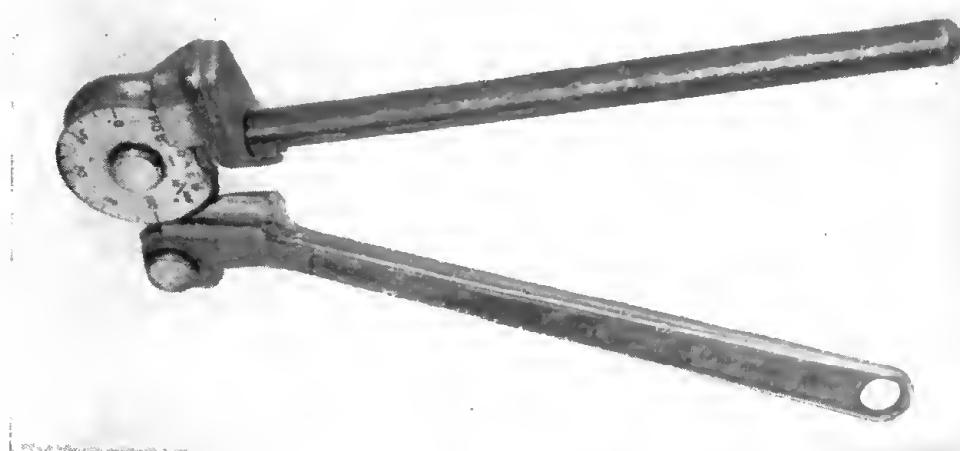
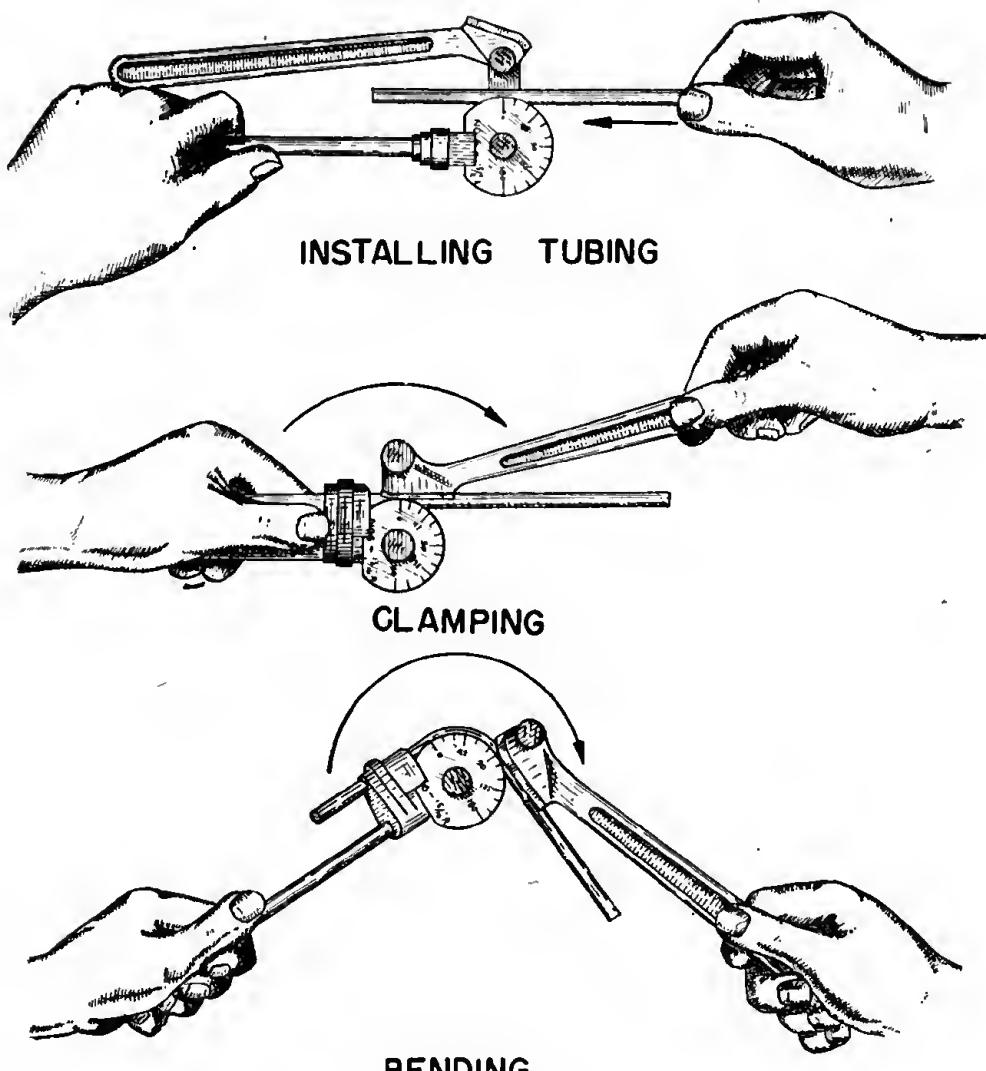


Figure 165. Tube-bending tool.



Method of using tube-bending tool.

a short arm which holds the tubing in place while it is being bent. (See fig. 165.)

(2) Most tube benders are made to bend copper and aluminum tubing only. Stainless-steel tubing may be bent, but there is danger of breaking the tube bender while bending it. Extreme caution should be exercised when attempting to bend stainless-steel tubing to avoid damage to the tube bender.

(3) Before bending a piece of tubing, the mechanic should make certain of the direction of bend and of the angle desired. This may seem foolish, but good mechanics have been known to make perfect bends—except that they were just 180° in the wrong direction.

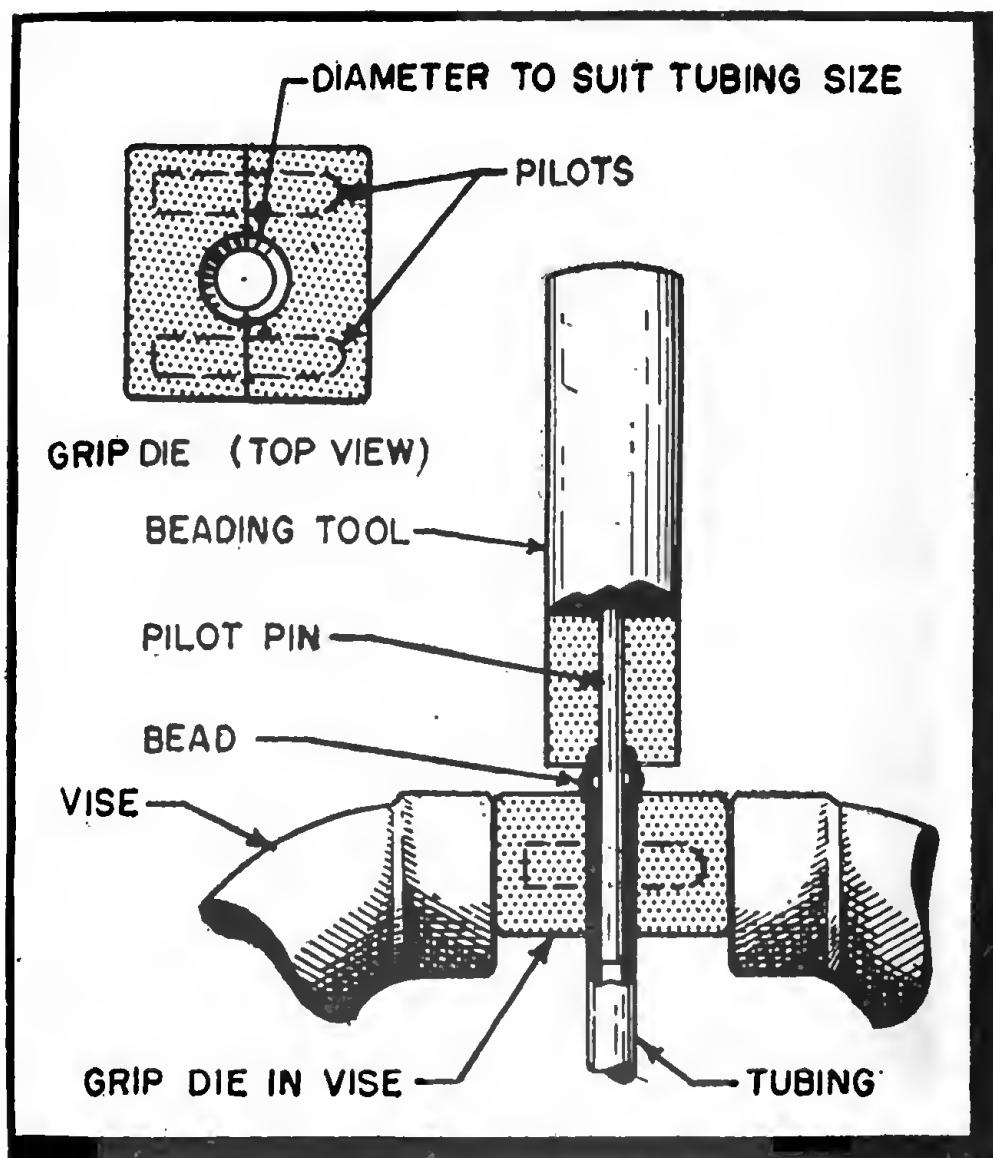


Figure 166. Tools for beading small tubing.

e. TUBE-BEADING TOOLS. Tubing-end hose connections and hose nipples have raised ridges (called beads) near the ends. These beads keep the clamp from slipping off the end of the tubing and thus prevent blow-off of the hose. Beading is usually done with beading tools, two types of which are shown in figures 166 and 167.

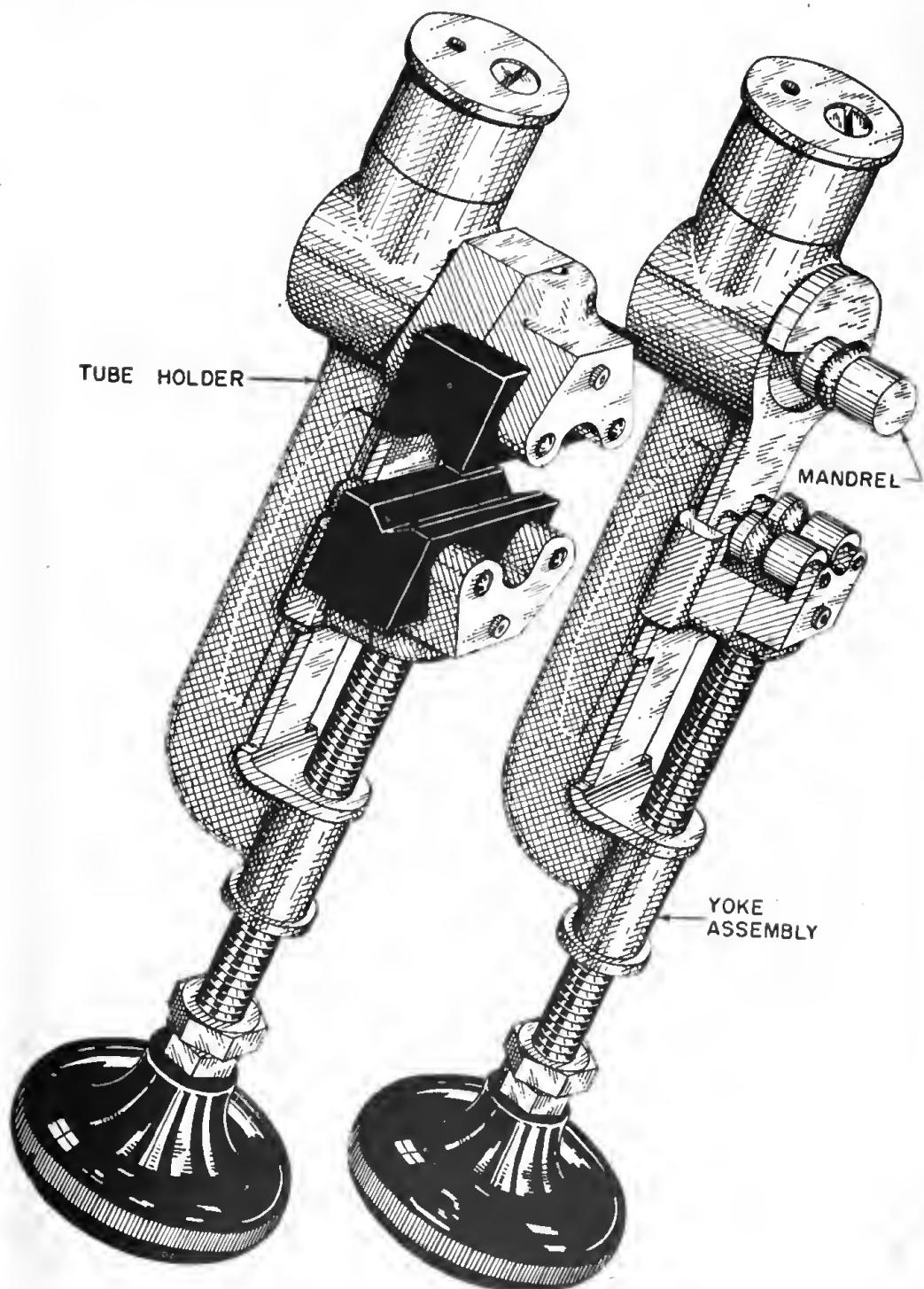


Figure 167. Tools for beading large tubing.

(1) The tool set shown in figure 166 is used for beading small tubing. It consists of a set of grip dies and a beading tool. The tubing is placed in the correct grip die and the die is clamped in a vise. (The tubing should extend approximately $1\frac{1}{2}$ diameters above the die.) The pilot pin is then placed in the open end of the tubing and the beading tool is struck lightly with a hammer until the desired bead has been formed.

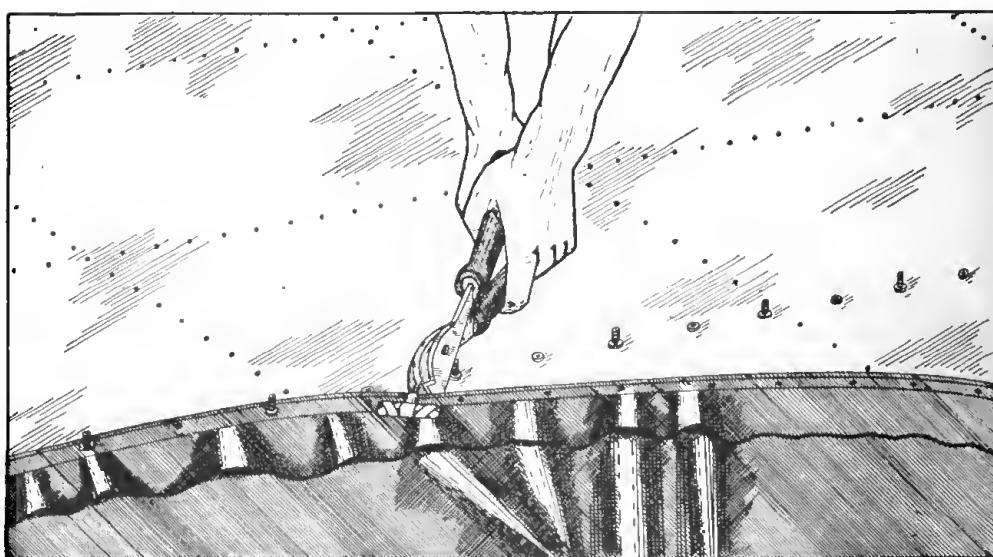
(2) For beading larger tubing, the tools shown in figure 167 are used. The end of the tubing is slipped over the mandrel and the handle of the yoke assembly is turned until the rollers bear against the outside of the tubing. The tube holder is then placed on the tubing (as near the yoke assembly as possible) and tightened. The yoke assembly is then rotated around the tubing. The handle should be tightened a little each turn until a bead of the desired height has been produced.

Note. If no beading tubes are available, a bead may be formed by wrapping wire (0.032 to 0.040 inch in diameter) around the tubing where the bead should be. The wire is then soldered to form the bead. This method can be used on all lines except aluminum and dural.

25. De-icer-installation Tools

a. GENERAL. It is necessary to remove and replace de-icer boots occasionally because of damaged condition, seasonal temperature changes, or transfer of the airplane from one locality to another. Special tools have been designed to do this job more efficiently. Most of these tools will ordinarily be fabricated at the field where they are needed.

b. DE-ICER-PULLING PLIERS. When a de-icer boot is installed, it is usually pulled on over riv-nut studs to hold it in place while the riv-nut screws are inserted. To provide a larger gripping surface to prevent tearing the de-icer boot, special pliers are usually used. These pliers have two



Use of de-icer-pulling pliers.

rods about 1 inch long welded perpendicularly to the jaws and wrapped with tape. (See fig. 168.)

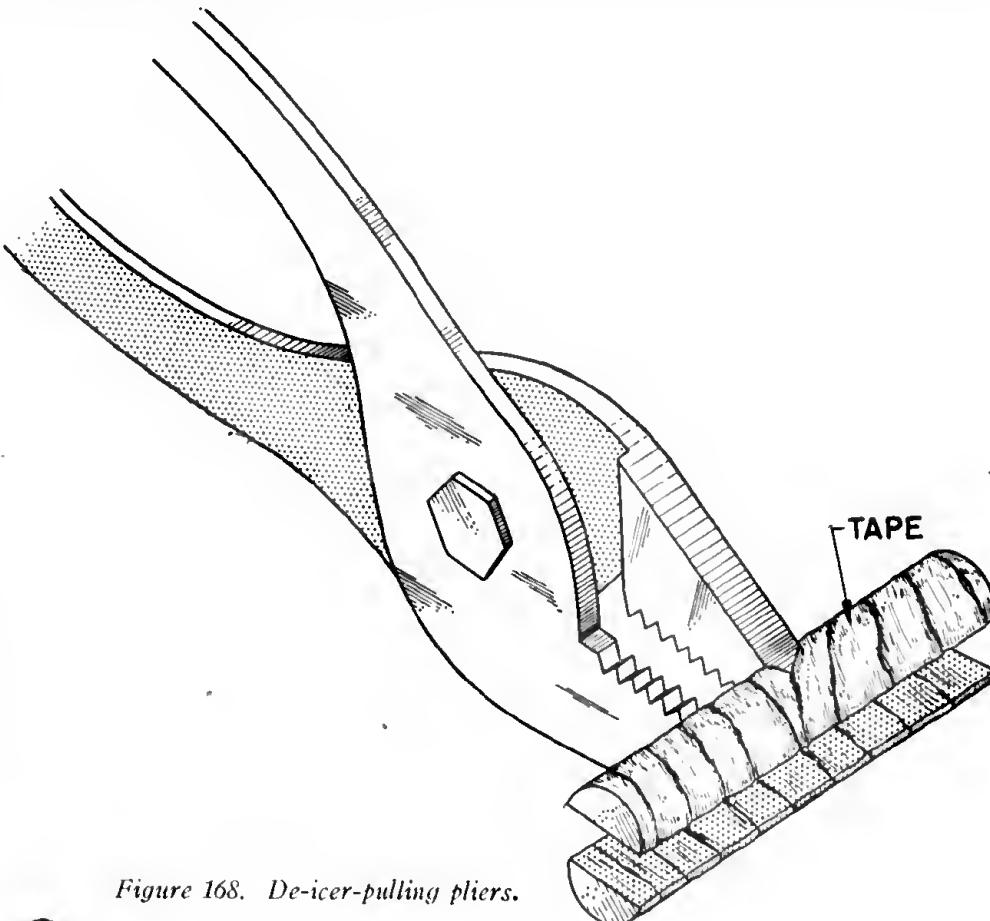


Figure 168. De-icer-pulling pliers.

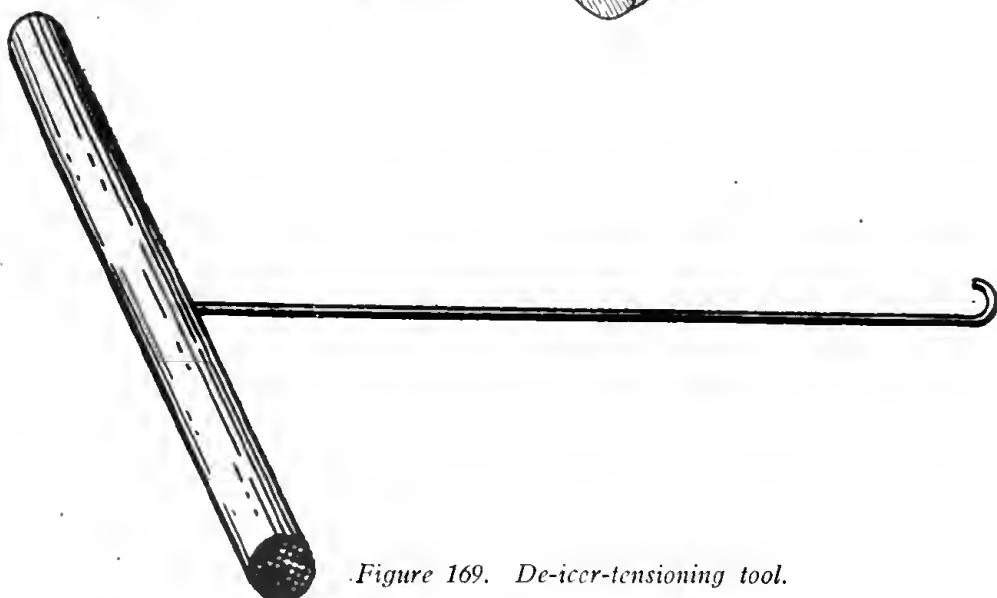


Figure 169. De-icer-tensioning tool.

c. DE-ICER-TENSIONING TOOL. The de-icer-tensioning tool shown in figure 169 is used when the pliers cannot be used. The hook is inserted through one of the holes in the boot to pull the boot to the desired position.

d. FAIRING-INDEXING TOOL. When it is necessary to fabricate a new fairing strip, the holes to be drilled in it may be accurately located by the fairing-indexing tool shown in figure 170. It is about 1 inch wide and

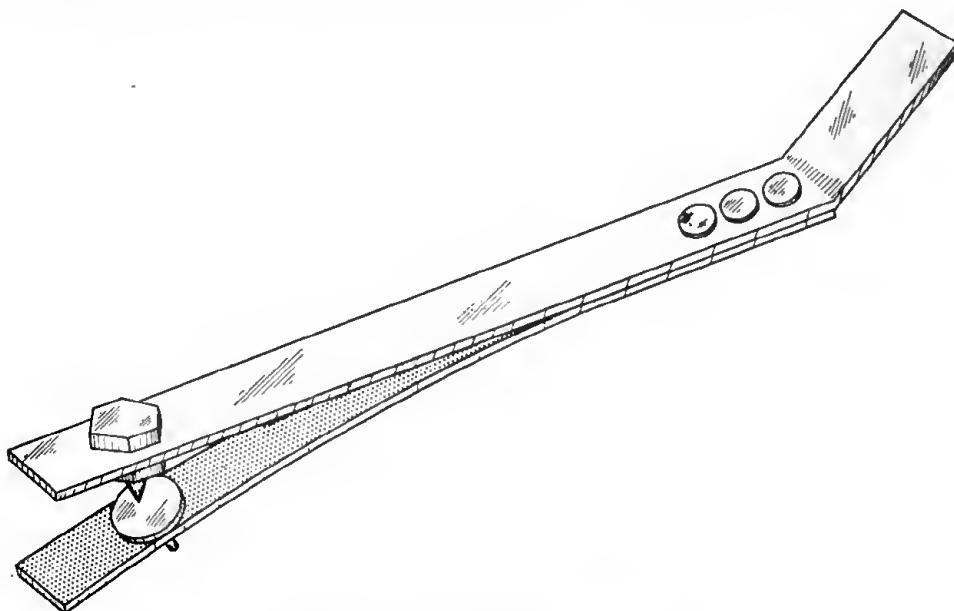
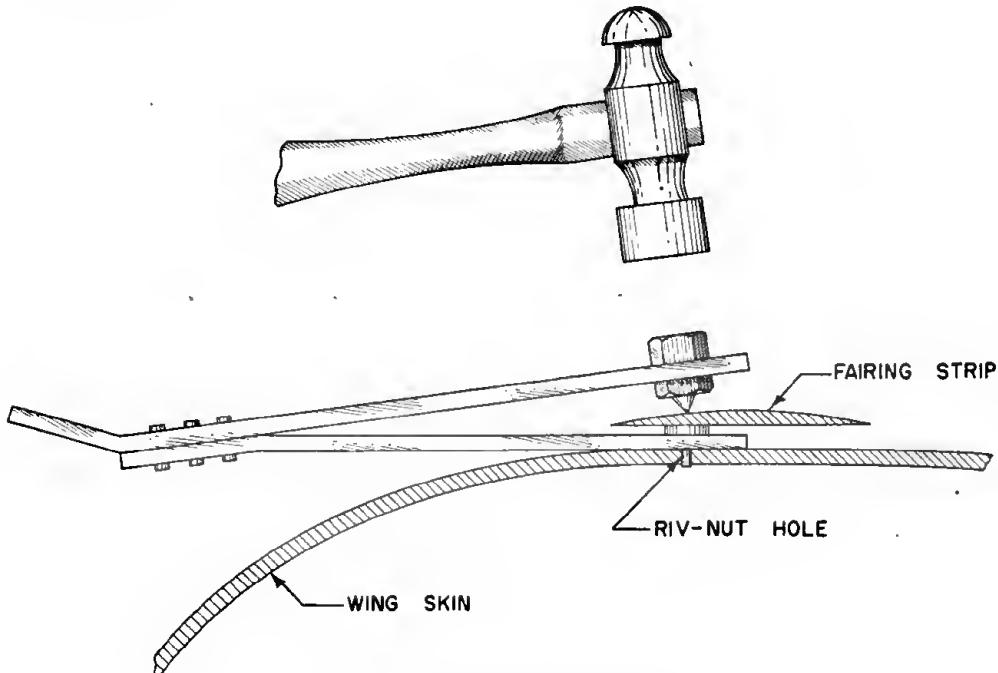


Figure 170. Fairing-indexing tool.

12 inches long. The two end holes of the fairing should be located and drilled first. Then with screws inserted through these holes, the remainder of the holes may be located without danger of the fairing strip slipping out of place.



Use of fairing-indexing tool.

e. SCREW-HOLDING PLIERS. Screw-holding pliers, used to start riv-nut screws, may be made by filing an ordinary pair of pliers as shown in figure 171.

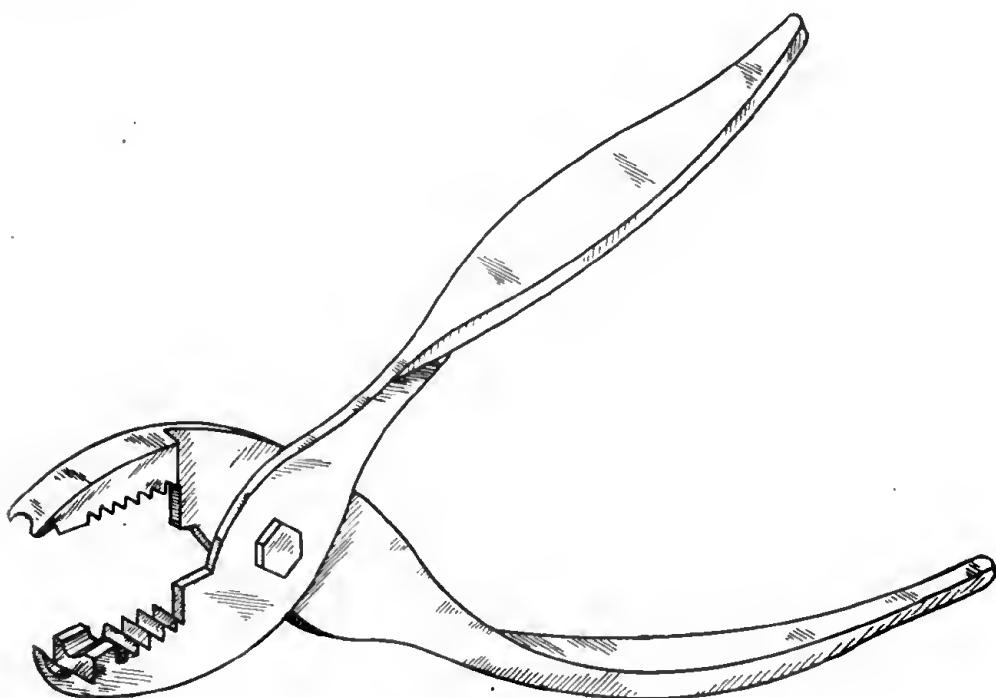


Figure 171. Screw-holding pliers.

f. RIV-NUT STUDS. (1) To hold the de-icer boot in place while the fairing strip is being applied and some of the riv-nuts are inserted, riv-nut studs are used. A riv-nut stud is merely a bolt of the proper size with the head cut off and filed smooth so that there will be no danger of cutting the boot. (See fig. 172.)

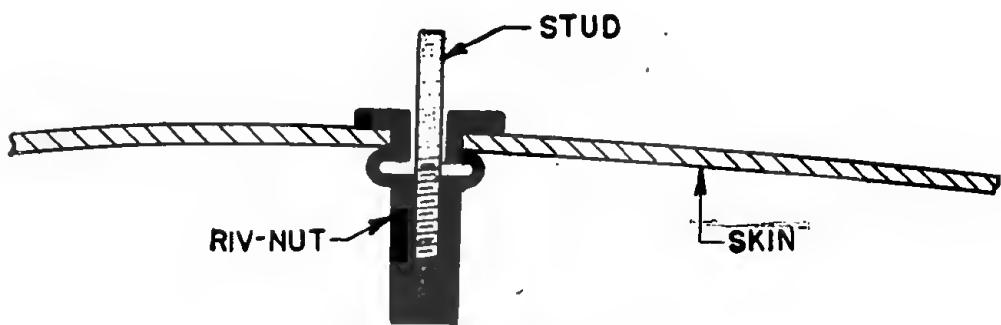


Figure 172. Riv-nut stud.

(2) A riv-nut stud is screwed into every second riv-nut and the boot is pulled into place over the studs. Next the fairing strip is put into place over the boot. The riv-nut screws are then installed. Then the studs are

removed and riv-nut screws are put into the holes from which the studs were removed.

g. LEATHER PUNCH. (1) A leather punch is used to cut the holes for the riv-nut screws in a de-icer boot. It is shaped like a pair of pliers, but has a sharp-edged tube mounted on one jaw and a plate on the other. (See fig. 173.)

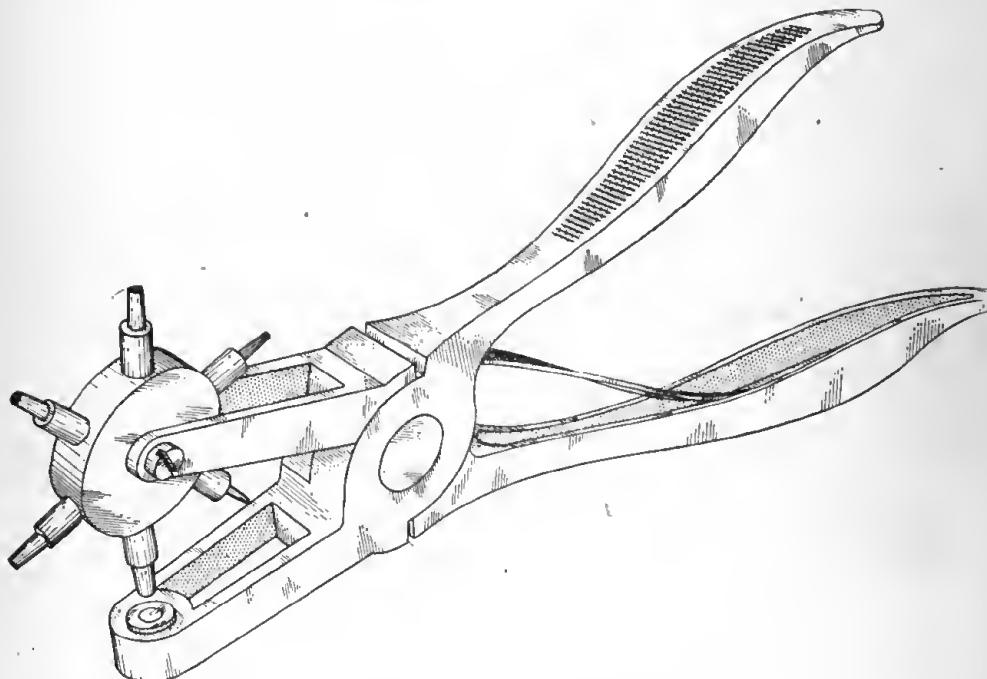
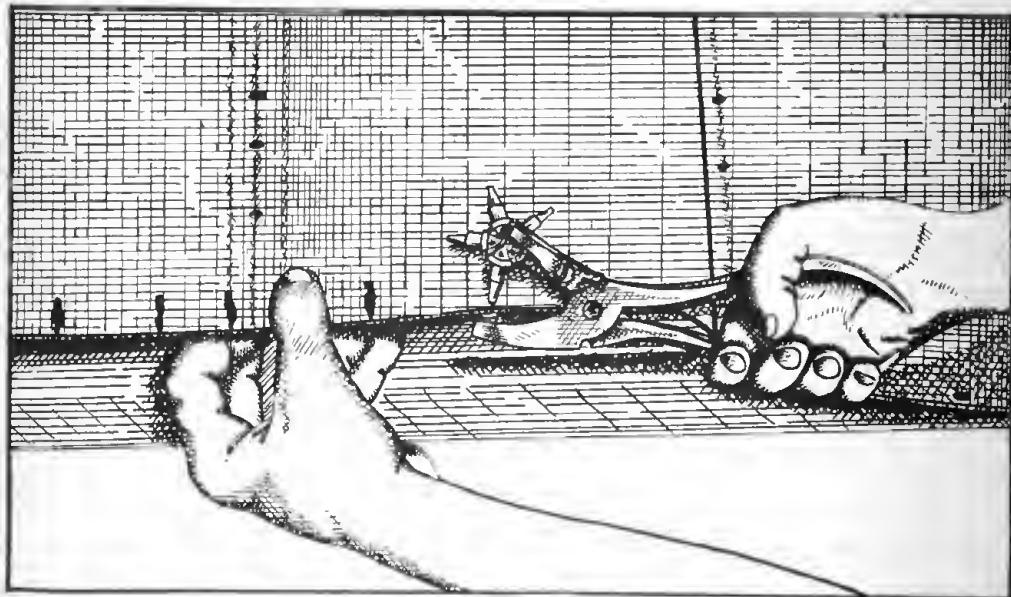


Figure 173. Leather punch.



Use of leather punch.

(2) The holes in the de-icer boot must be located accurately if the boot is to fit properly. One good method of locating the holes properly is to hold the de-icer boot and fairing strip together and punch the holes directly through the holes in the fairing strip.

(3) The leather punch is made to punch holes in leather, rubber, or cloth. Under no circumstances should an attempt be made to cut holes in metal with it.

h. Awl. An awl is shown in figure 174. This tool is used to line up the holes in the boot with the holes in the fairing strip when attaching a de-icer boot.

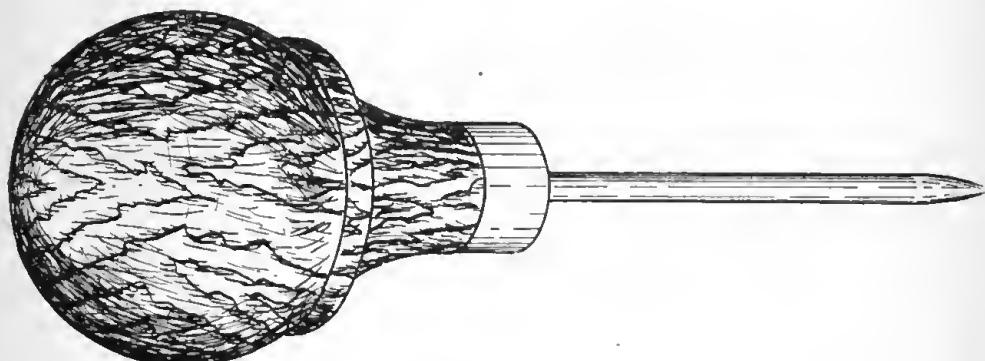


Figure 174. Awl.

i. ROLLER. A roller such as the one shown in figure 175 is used to roll the flaps of a de-icer boot when cementing them to the wing.

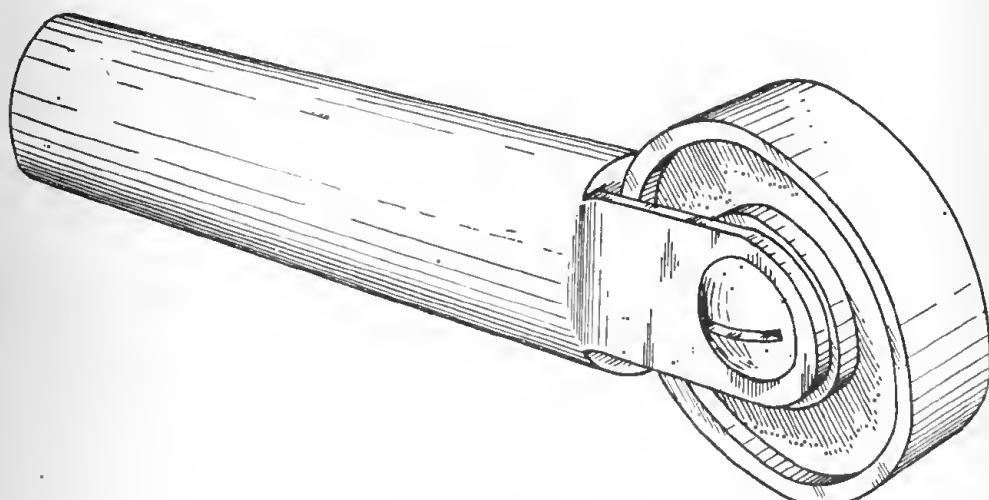
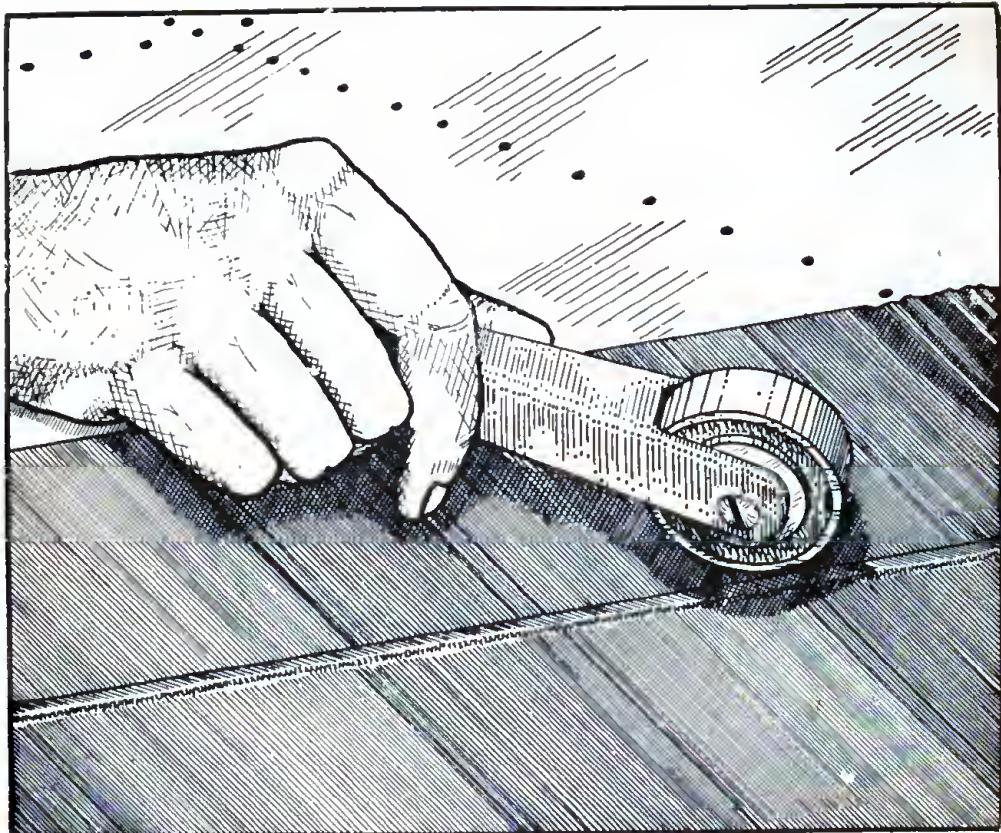


Figure 175. De-icer roller.



Rolling flaps of de-icer boot.

26. Miscellaneous Fabricating Tools

a. EMERY CLOTH. Emery cloth is used on metal as sandpaper is used on wood. It serves well for polishing metal, but is not satisfactory for working metal to a given level. It is graded according to the size of the emery grains. Common grades range from No. 000 to No. 3½. No. 3½ emery cloth is much finer than No. 3⅓ sandpaper.

b. CROCUS CLOTH. Crocus cloth is a very fine polishing cloth of crocus-purple color. It is used to remove small rust spots and for other similar work.

c. BUFFER. Cloth disks set on a shaft to be driven by an electric motor are called buffers. They are used to polish metal and other materials. They are usually used with a polishing compound. When using a buffer, the mechanic should not allow it to remain in one spot too long or overheating will result.

d. FIGURE AND LETTER STAMPS. (1) A set of figure and letter stamps includes one each of all the letters in the alphabet, one each of the numbers 0 through 9, and the figure &. Each stamp is a steel die about 3 inches long with a character shaped on its face. (See fig. 176.) The face is hard steel. The stamps are used to cut identification marks into materials and tools.

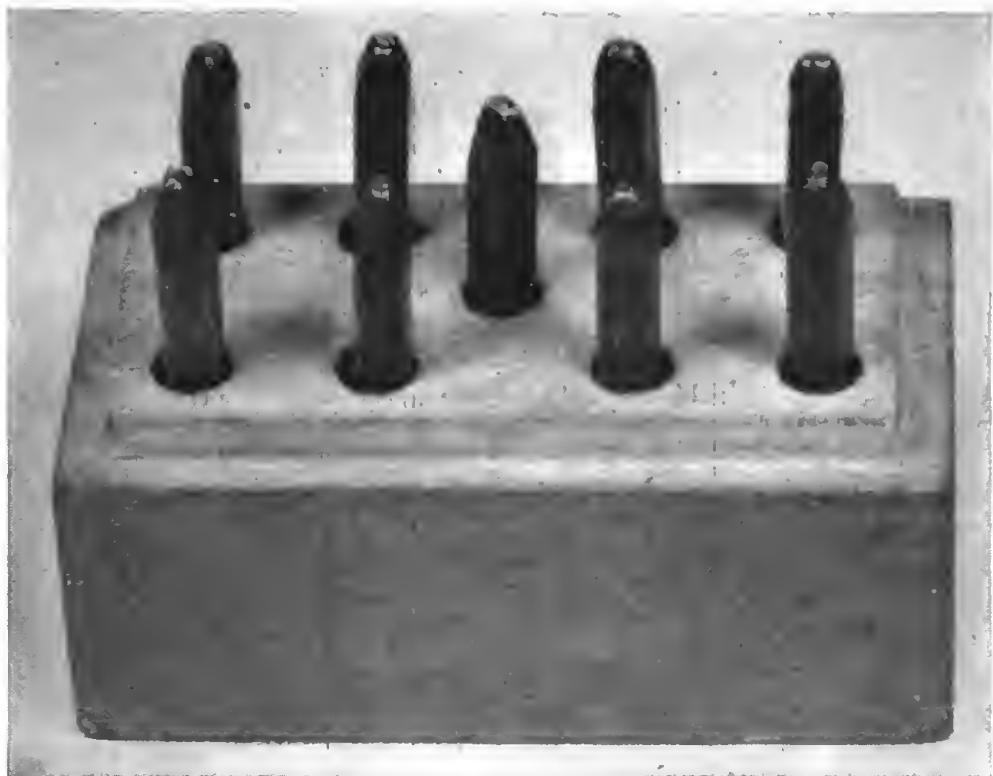


Figure 176. Set of figures.

(2) To mark a piece of material, the proper stamp is held perpendicularly to the surface of the material and struck one blow with a hammer. Striking the stamp more than once will make a blurred cut and should be avoided.

(3) Some materials should not be marked with figure and letter stamps. The marking distorts, strains, and weakens the material slightly. On pieces of equipment that might be damaged seriously by the stamps, identification should be made in some other manner, such as with an electric pencil.

e. SWAGING ASSEMBLY. A swaging assembly is shown in figure 177. It is used to fasten the end of a control cable to a fitting. The swaging assembly actually squeezes the metal of the fitting around the end of the control cable. It has individual dies to be used for the various-sized fit-

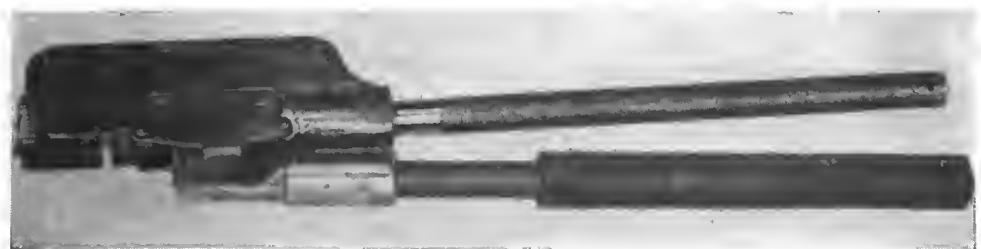


Figure 177. Hand-swaging assembly.

tings. It should be used according to the directions furnished with it. It is lubricated with high-pressure grease, not oil.

f. SOLDERLESS TERMINAL-STAKING TOOLS. These tools are used to install solderless electrical terminals. Two types are shown in Figure 178. The tool shown in figure 178① is used to install terminals on No. 10 or smaller wire. Terminals are installed on No. 8 or larger wire with the tool shown in figure 178②. To install a terminal (fig. 179), skin the

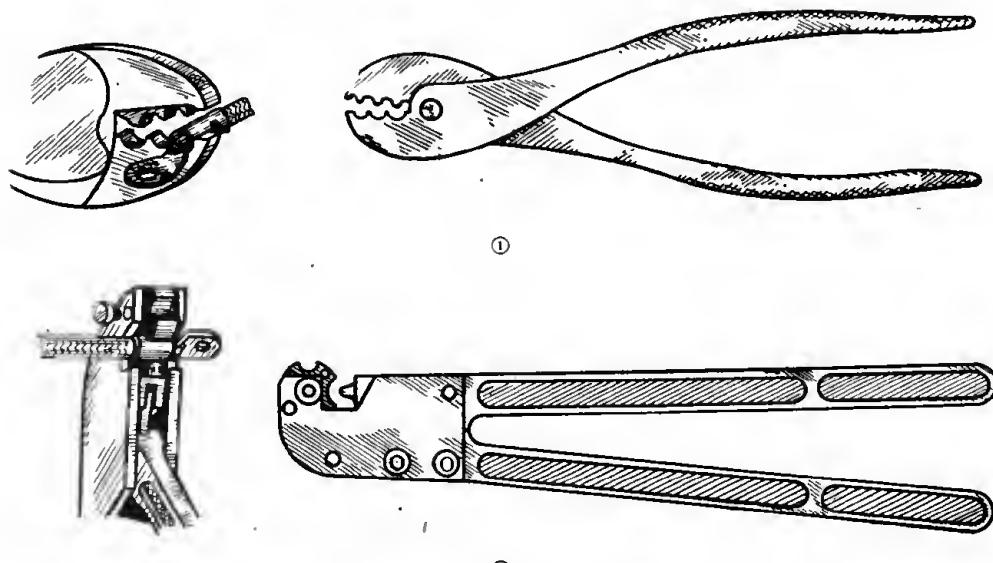


Figure 178. Solderless-terminal staking tools.

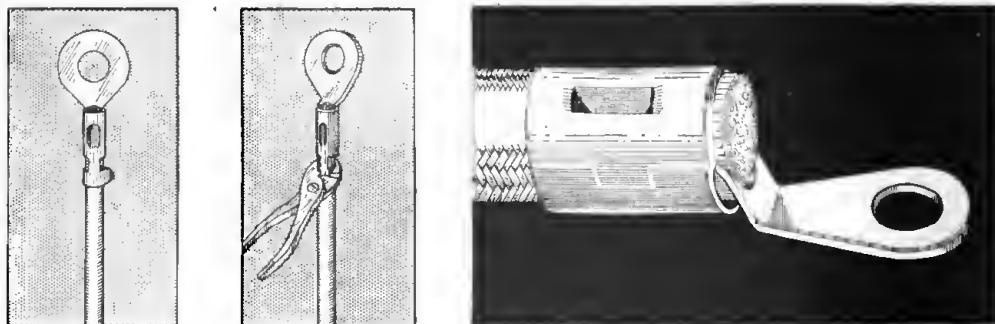
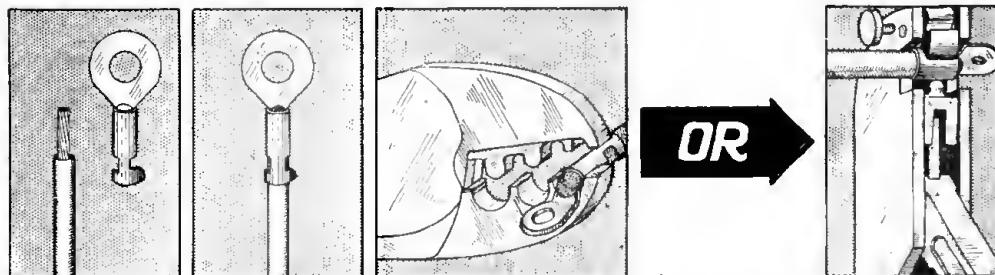


Figure 179. Method of installing solderless terminals.

wire, insert the wire in the terminal, place the terminal in the correct nest, and close the tool once all the way. If the terminal has ears, they should be closed. When using the smaller tool, the white handle should be up. When using the larger tool, lock the wheel at the correct nest before inserting the terminal.

SECTION VI

POWER TOOLS

27. General

Power tools are used whenever the amount of work to be done is great enough to justify their use. They are naturally more expensive than hand tools, but will greatly increase the mechanics' efficiency. Power tools require more care and skill than hand tools and are more likely to injure the operator. They should be lubricated when necessary, but too much lubrication will ruin electric motors.

28. Electric Drill

a. GENERAL. One of the most common of the power tools is the electric drill. (See fig. 180.) It has a small, high-speed electric motor geared to the chuck through reduction gears. It is used for drilling holes in metal and other similar work.

b. SIZE AND SPEED. Electric drills are made in various sizes. The

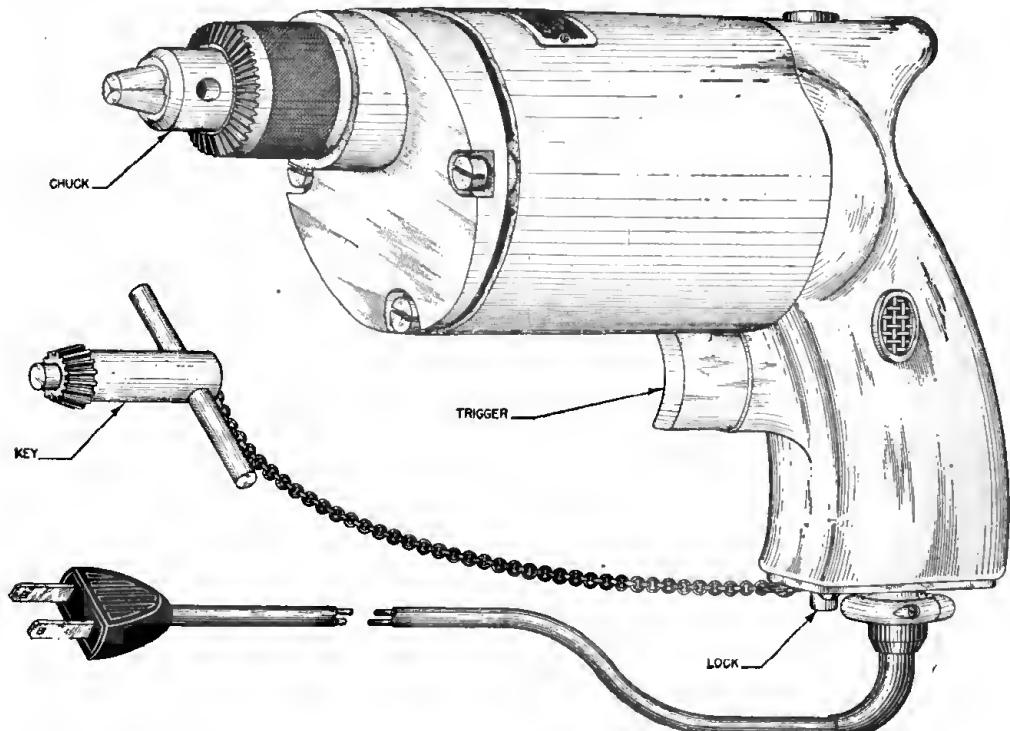


Figure 180. Electric drill.

size indication of an electric drill refers to the largest size hole it will drill in mild steel. Common sizes are $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ inch. The speed at which an electric drill runs will depend upon its size. The reason for this is that large twist drills must rotate more slowly than small ones in order not to overheat. The chuck of an electric drill is made so that it will not accommodate a twist drill larger than the electric motor can manage. This helps prevent overloading the motor and stalling the drill. Drills smaller than the maximum capacity of the electric drill may be held, but it is not good practice to use a very small twist drill in a large electric drill. It is better to use the smallest electric drill that will hold the particular size twist drill being used. There are two reasons for this. The large electric drill is heavier and harder to hold. It runs more slowly and so does not cut as fast.

c. USE AND CARE. To drill a hole with an electric drill, choose the proper size of twist drill, make sure it is sharp, and fasten it in the chuck. It should be fastened securely so that it cannot slip. If it slips, the shank of the drill will be scored. The center of the proposed hole should be plainly marked with a center punch. The point of the drill is applied to the center-punch mark and the drilling begun. The twist drill does not draw itself into the work. Therefore, enough pressure must be applied by the mechanic to cause the drill to cut. Too much pressure must not be applied as it might stall the motor or break the drill. If the hole is to be drilled completely through the stock, the pressure must be reduced when the point of the drill begins to emerge from the stock.

29. Electric Grinder

a. GENERAL. An electric grinder consists of an electric motor with a grinding wheel mounted on each end of the motor shaft. It will also have the necessary guards and shields to protect the operator from injury. Usually, one of the wheels is coarse, to be used for rough work, and the other wheel is fine, to be used for sharpening tools. There are two models of grinders: the bench grinder which sits on a bench (fig. 181 ①) and the pedestal grinder which is bolted to the floor. (See fig. 181 ②.)

b. SIZE. The size of a grinder is indicated by the horsepower of the motor, not the diameter of the wheel. Common sizes are $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 horsepower.

c. USE AND CARE. (1) When a wheel is installed on a grinder, it should first be tested to make sure it is sound. A sound wheel will give off a dull ring when held in one hand and tapped with a wooden object. A cracked wheel will give off a dull thud. A cracked wheel is definitely dangerous and should be discarded. A metallic object should not be used to test a grinding wheel as this might break it. The wheel should slip easily onto the arbor. Usually it will have 0.003- to 0.005-inch clearance. A piece of blotting paper or similar substance should be placed on each side between the wheel and the wheel flanges. (See fig. 182.) The



Figure 181 ① Electric bench grinder.

flanges should be of ample size. The nut which holds on the wheel should be tightened snugly, but not too much. After the wheel is mounted, it should be rotated a few times by hand to make sure it is balanced.

(2) To function properly, a grinding wheel must be true. With use, the surface of the wheel will wear unevenly and will have to be dressed. One type of wheel dresser is shown in figure 183. To dress a grinding wheel, the wheel dresser is placed against the wheel while it is running. The dresser is moved back and forth until the wheel is true. If the disk dresser is used, it should be held against the grinding wheel tightly enough to prevent it throwing off sparks.

(3) Grinding causes materials to heat. Some grinders are equipped with water pumps which pump a steady stream of water over the work. If the grinder is not equipped with a water pump, the work should be dipped in water often enough to prevent overheating. This is particularly important when sharpening cutting tools.

(4) Most grinding wheels are not designed to grind soft materials such as aluminum and brass. These will clog the pores of the wheel and stop its cutting action. A clogged or glazed wheel should be dressed to make it cut properly.

d. SAFETY PRECAUTIONS. An electric grinder is considered one of the dangerous tools. One should never use it without wearing goggles. This is true whether the grinder is equipped with a shield or not. A grinder



Figure 181 ②. Electric pedestal grinder.

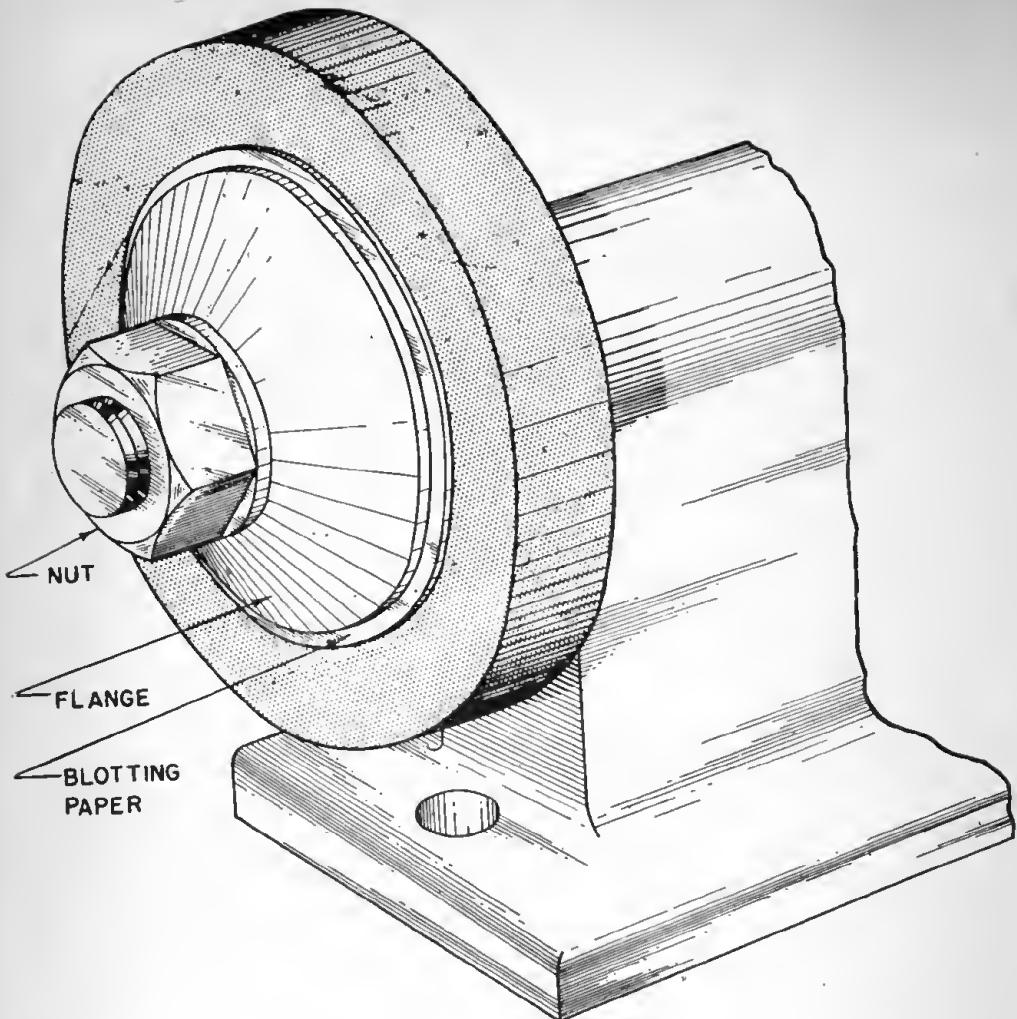


Figure 182. Mounted grinding wheel.

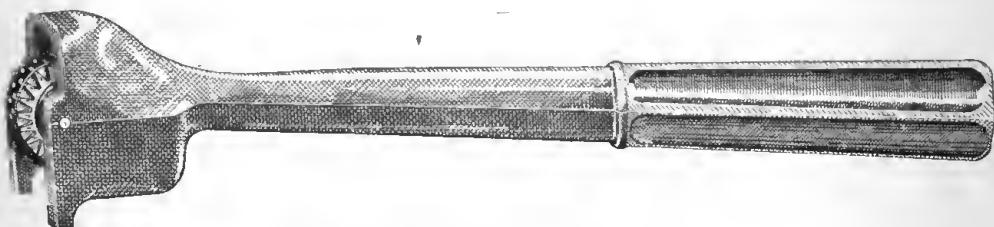
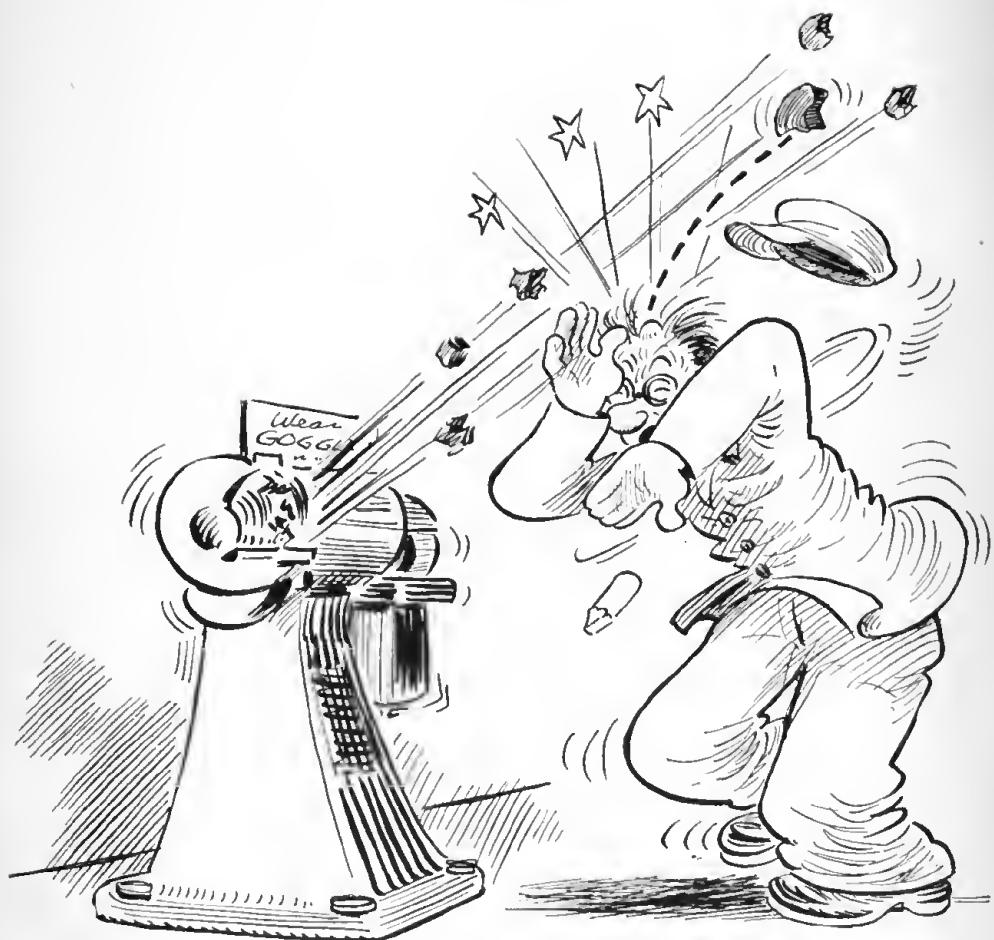


Figure 183. Grinding-wheel dresser.

should never be used without the wheel guards attached. If a wheel breaks and a piece of the wheel strikes the mechanic on the head, it may cause fatal injury. One of the most common accidents with a grinder is injury to the fingers or thumb. The mechanic should hold the material he is grinding in such a way that his fingers will not touch the grinding wheel if the material slips.



*Exercise care when using grinders.
They are dangerous tools.*



*If you don't want to grind your fingers, keep them
away from the wheel.*

30. Spray Gun

a. GENERAL. A spray gun is used to apply lacquers and dope. It usually has a continuous stream of compressed air flowing through it. The flow of lacquer is controlled by a needle valve. When the operator opens the needle valve, the air stream draws up the lacquer, atomizes it, and blows it onto the work where it sticks and dries. There is a regulating screw on the gun so that the amount of lacquer being applied may be controlled. (See fig. 184.)



Figure 184. Spray gun.

b. USE AND CARE. Surfaces to be lacquered should be clean and dry. The gun should be regulated to apply as much lacquer as possible without having it so thick on the surface that it runs. The amount of lacquer applied to a surface depends upon the volume discharged from the gun and the rate at which the gun is moved. The spray gun should be cleaned immediately after use as the lacquer is still wet and is easier to remove.

c. SAFETY PRECAUTIONS. Once in a while one hears of a spray gun exploding. This may be caused by too much air pressure. Care should

be exercised to prevent too much air pressure in the gun, especially in the paint container.

31. Grease Gun

There are several different types of grease guns. One of these is shown in figure 185. Air pressure is used to force the grease into a grease fit-

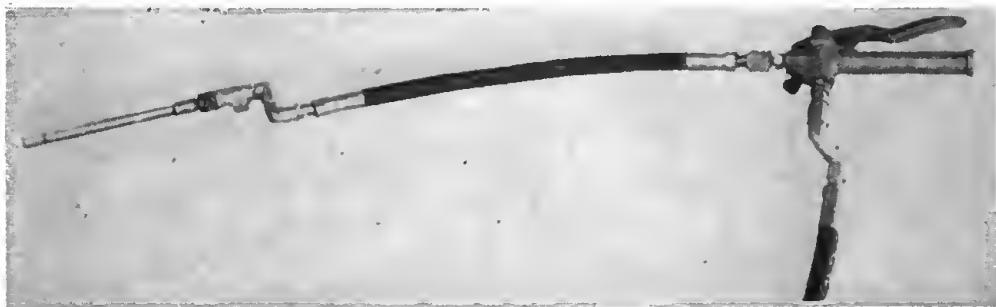


Figure 185. Grease gun.

ting. The fitting should be wiped off before using the grease gun to prevent the entrance of dirt into the part being greased.

32. Oil-spray Gun

Oil-spray guns operate on the same principle as paint-spray guns. The nozzle of an oil-spray gun is long enough to reach out of the way places. (See fig. 186.) The oil-spray gun is used with kerosene or gasoline to



Figure 186. Oil-spray gun.

clean an engine, or it may be used to apply the pickling solution on an engine that is being placed in storage. The battery of an airplane should always be disconnected before using an oil-spray gun. The nozzle might otherwise cause a short circuit and start a serious fire.

INDEX

	<i>Paragraph</i>	<i>Page</i>
Adjustable-jaw wrench	2	3
Aircraft tools (<i>see Tools</i>).		
Allen wrenches	2	3
Assembly and disassembly tools.....	2-5	3
Auto wrenches	2	3
Awl	25	134
Ball-peen hammer	5	16
Bearing puller	7	19
Bench vise	19	66
Bits, wood	20	70
Blade beam	8	31
Blowtorches	22.	120
Cautions in using	22	120
Box-end wrench	2	3
Brace	20	70
Brake-bleeding tool	9	33
Brush	23	124
Holder	23	124
Buffers	26	140
Calipers:		
Hermaphrodite	13	52
Slide pocket	13	52
Spring	13	52
Camloc pliers	21	86
Carriage clamp	19	66
Chisels:		
Cold	21	86
Use of	21	86
Woodworking	20	70
Chrome-molybdenum steel	2	3
Cleco fasteners	21	86
Cloth:		
Crocus	26	140
Emery	26	140
Cold chisels	21	86

	<i>Paragraph</i>	<i>Page</i>
Coppers, soldering	22	120
Cotter-pin extractor	9	33
Countersink, wood	20	70
Crescent wrenches	2	3
Crocus cloth	26	140
 De-icer tools	25	134
Depressor:		
Rocker-arm	7	19
Valve-spring	7	19
Depth micrometer	14	56
Diagonal-cutting pliers	3	11
Dies	21	86
Dimpling tools	21	86
Dividers	15	64
Drill-grinding gauge	12	46
Drills	21	86
Electric	28	144
Sharpening	21	86
Use of	21	86
Dzus fasteners, repair of	21	86
 Elbow wrench, spark plug.....	7	19
Electric:		
Drill	28	144
Grinder	29	145
Emery cloth	26	140
Extractor:		
Cotter-pin	9	33
Screw	2	3
Tap	21	86
Ezy-out	2	3
 Fabric-working tools	23	124
Fabricating tools	18-26	66
Fairing-strip indexing tool	25	134
Fastener-repair tools	21	86
Figure and letter stamps.....	26	140
Files	21	86
Cleaning	21	86
Use of	21	86
Finger, mechanical	9	33
Flux, soldering	22	120
 Gauges:		
Drill-grinding	12	46
Go, no-go	12	46
Radius	12	46

	<i>Paragraph</i>	<i>Page</i>
Gauges:—Continued		
Sheet-metal and wire	12	46
Thickness	12	46
Thread	12	46
Twist-drill	12	46
Valve-clearance	12	46
Gear and bearing puller.	7	19
General maintenance tools.	21	86
Glue	20	70
Go, no-go gauges	12	46
Gouge, woodworking	20	70
Grease gun	31	152
Grinders, electric	29	145
Grinding wheels:		
Dressing	29	145
Installation	29	145
Gun:		
Grease	31	152
Spray	30	151
Oil-spray	32	152
Hacksaws	21	86
Hammers:		
Ball-peen	5	16
Brass	5	16
Plastic	5	16
Rawhide-mallet	5	16
Sledge	5	16
Use and care of	5	16
Handles, socket-wrench	2	3
HandscREW	19	66
Hardening	1	1
Heat treatment of tools	1	1
Hermaphrodite calipers	13	52
Hinged-socket handle	2	3
Holding devices	19, 21	66, 86
Hose-clamp wrench	7	19
Importance of tools	1	1
Inside micrometer	14	56
Knife:		
Pocket	20	70
Putty	23	124
Layout tools	1, 15, 16	1, 64
Long-nose pliers	3	11
Machinist hammer	5	16
Measuring tools	1, 10-14, 17	1, 43, 64

	<i>Paragraph</i>	<i>Page</i>
Mechanical finger	9	33
Metalworking tools	21	86
Micrometers:		
Principle of operation	14	56
Reading	14	56
Size	14	56
Types	14	56
Use and care of	14	56
Needles	23	124
Nonmagnetic screw drivers.....	4	12
Offset screw drivers.....	4	12
Oil:		
Flange wrench	7	19
Pump puller	7	19
Sump stud wrench	7	19
Open-end wrench	2	3
Outside micrometer	14	56
Phillips screw drivers.....	4	12
Pinking shears	23	124
Pipe wrenches	2	3
Piston-moving tool, propeller.....	8	31
Plane	20	70
Sharpening	20	70
Pliers	3, 25	11, 134
Pocket knife	20	70
Power tools	1, 27-32	1, 144
Propeller:		
Blade beam	8	31
Piston-moving tool	8	31
Proper use of tools.....	1	1
Protractor assembly	8	31
Use of	8	31
Pullers:		
Gear and bearing	7	19
Oil-pump	7	19
Pulling pliers, de-icer.....	25	134
Punches	21	86
Leather	25	134
Pushrod cover-nut wrench.....	7	19
Putty knife	23	124
Quenching liquid	1	1
Radius gauge	12	46
Rasp	20	70

	Paragraph	Page
Ratchet handle, socket.....	2	3
Reed and Prince screw drivers.....	4	12
Riveting tools	21	86
Riv-nut studs	25	134
Roller, de-icer	25	134
Rules	11	43
 Sandpaper	20	70
Saws	20	70
Sharpening	20	70
Screw extractor (Ezy-out)	2	3
Screw-holding pliers	25	134
Screw drivers:		
Nonmagnetic	4	12
Offset	4	12
Phillips	4	12
Reed and Prince	4	12
Safety precautions	4	12
Sharpening of	4	12
Selection and use of	4	12
Spiral-ratchet	4	12
Types	4	12
Scribers	16	64
Segment, timing	17	64
Sharpening stone	20	70
Shears, pinking	23	124
Sledge	5	16
Sliding bar-pocket handle.....	2	3
Slide-pocket calipers	13	52
Slip-joint pliers	3	11
Socket wrenches	2	3
Socket-wrench handles	2	3
Soldering:		
Coppers	22	120
Tools	22	120
Pointers on	22	120
Solderless terminal-staking tools.....	26	140
Spanner wrenches	8	31
Spark plug:		
Elbow wrench	7	19
Wrench	7	19
Special aircraft tools	1, 6-9, 17	1, 19, 64
Speed-pocket handle	2	3
Spiral-ratchet screw drivers.....	4	12
Spray guns	30	151
Oil	32	152
Spring calipers	13	52
Stamp, figure and letter.....	26	140

	<i>Paragraph</i>	<i>Page</i>
Starter and generator-stud nut wrench.....	7	19
Stone, sharpening	20	70
Straight edge, timing.....	17	64
Stud, riv-nut	25	134
Swaging assembly	26	140
 Tapes	11	43
Taps	21	86
Tempering	1	1
Tensiometers	9	33
Use of	9	33
Tensioning tool, de-icer.....	25	134
Thickness gauge	12	46
Thread micrometer	14	56
Timing:		
Segment	17	64
Straight-edge	17	64
Tool:		
Hardening	1	1
Material	1	1
Tempering	1	1
Tools:		
Aircraft	1	1
Assembly	2-5	3
Care of	1	1
Classes	1	1
Disassembly	2-5	3
Fabricating	1	1
General maintenance	11	43
Heat treatment	2-3	3
Importance	1	1
Measuring and layout.....	1, 10-17	1, 43
Proper use of	1	1
Power	1, 27, 32	1, 144, 152
Tube:		
Bending tools	24	126
Bending tool	24	126
Cutting tool	24	126
Flaring tools	24	126
Tubing:		
Nut wrench	9	33
Tools	24	126
Turnbuckle wrench	9	33
Twist-drill gauge	12	46
 Valve:		
Clearance gauge	12	46
Repair tool	9	33
Spring depressor	7	19

	<i>Paragraph</i>	<i>Page</i>
Valve:—Continued		
Stem-fishing tool	9	33
Tappet-adjusting screw and nut wrench.....	7	19
Vise:		
Bench	19	66
Saw	20	70
Woodworking	19	66
Water-pump pliers	3	11
Woodworking materials	20	70
Tools	20	70
Vise	20	70
Wrenches:		
Adjustable-jaw	2	3
Allen	2	3
Auto	2	3
Box-end	2	3
Crescent	2	3
General	2	3
Hose-clamp	7	19
Open-end	2	3
Oil-flange	7	19
Oil-sump stud	7	19
Palnut	7	19
Pipe	2	3
Pushrod cover-nut	7	19
Socket	2	3
Spanner	8	31
Spark-plug	7	19
Elbow	7	19
Special	6-9	19
Stud:		
Installing	7	19
Removing	7	19
Starter and generator stud-nut.....	7	19
Torque	7	19
Tubing nut	9	33
Turnbuckle	9	33
Types of	2	3
Use and care.....	2	3
Valve tappet-adjusting screw and nut,.....	7	19

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